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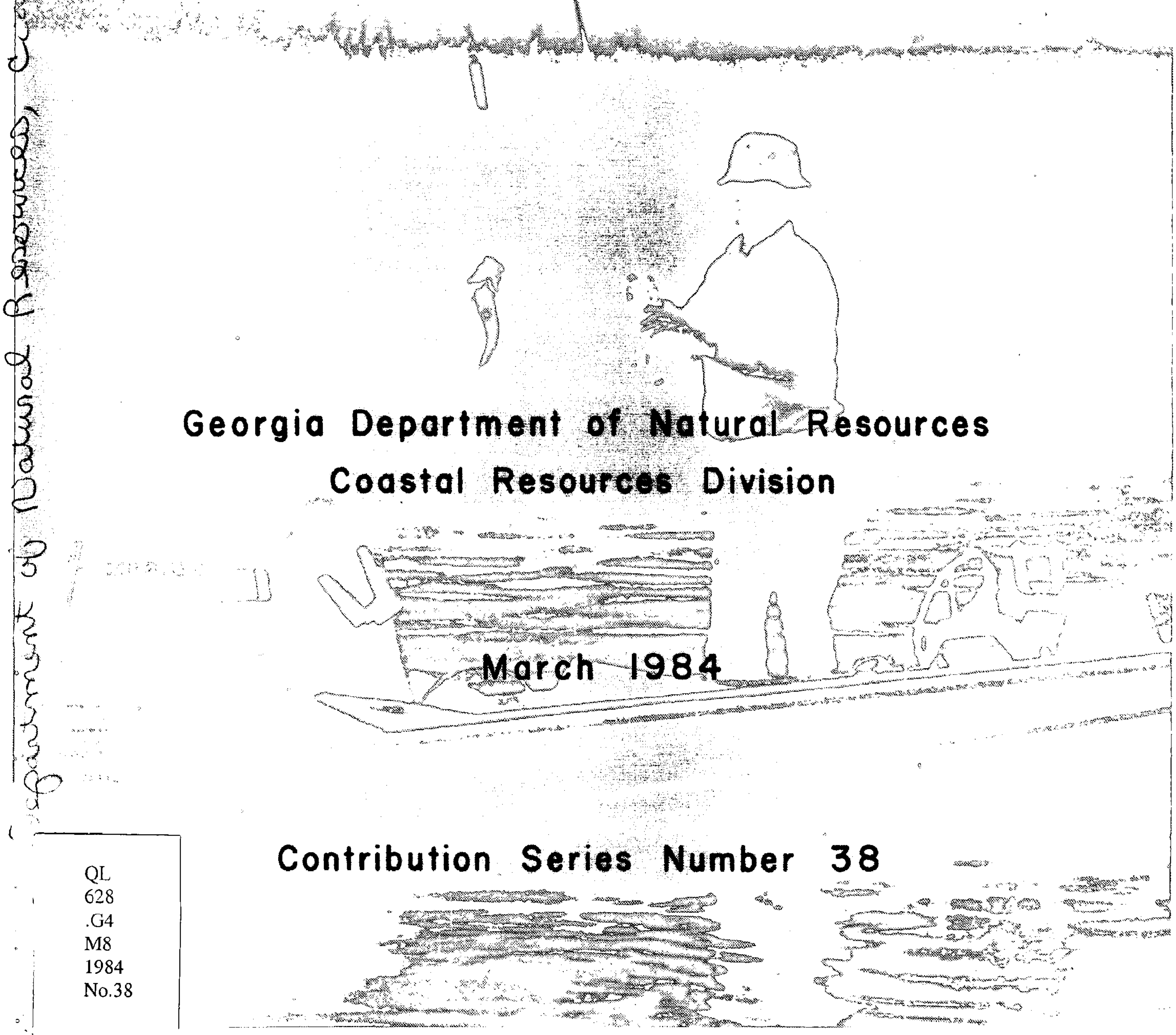
POPULATION DYNAMICS AND LIFE HISTORY ASPECTS OF MAJOR MARINE SPORTFISHES IN GEORGIA'S COASTAL WATERS



Georgia Department of Natural Resources

Coastal Resources Division

March 1984

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POPULATION DYNAMICS AND LIFE HISTORY ASPECTS OF MAJOR MARINE SPORTFISHES IN GEORGIA'S COASTAL WATERS

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FINAL REPORT

STATE: GEORGIA   PROJECT: F-31-6

PROJECT TYPE: SURVEY

STUDY TITLE: Population Dynamics and Life History Aspects of Major Marine Sportfishes in Georgia's Coastal Waters.

PERIOD COVERED: 1 July 1978 - 30 June 1983.

STUDY OBJECTIVES:

1) To conduct a comprehensive study of seasonal movements and migration patterns of the eleven most important inshore marine recreational species of sportfishes.

2) To determine age and growth characteristics (time of annulus formation, size at various annuli, rates of growth, etc.) of the eleven target species.

3) To determine the food preferences and feeding habits of the target species and determine if seasonal and/or developmental changes in habits or diets occur.

4) To determine the reproductive characteristics (time of spawning, location of spawning, age at maturity, fecundity, etc.) of the target species.

ABSTRACT

Various aspects of the life histories of 11 species of Georgia's inshore marine recreational sportfishes were investigated in the coastal waters of Glynn County from July 1978 through June 1982, to establish a data base to be used in making future management decisions concerning Georgia's marine recreational fishery. Species selected for study were spotted seatrout (*Cynoscion nebulosus*), weakfish (*C. regalis*), red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), southern flounder (*Paralichthys lethostigma*), summer flounder (*P. dentatus*), sheepshead (*Archosargus probatocephalus*), Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), southern kingfish (*Menticirrhus americanus*), and gulf kingfish (*M. littoralis*). Movements and migration patterns were determined through mark-recapture (tagging) studies; age and growth were determined through scale and otolith examination techniques; maturity and spawning information were determined through direct examination of the gonads; and feeding habits were determined through analyses of stomach contents. A summary of findings and management recommendations are also included.

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INTRODUCTION

Georgia is unique among other coastal states in both its fishery resources and its user groups. The vast expanse of saltmarsh vegetation and the associated network of tidal creeks and rivers create an ideal nursery system for countless species of fish and invertebrates. Consequently, these areas harbor excellent opportunities for coastal anglers who prefer fishing in protected inshore waters. Georgia is also unique among other coastal states in that the finfish fishery is practically devoid of competition from commercial fishing operations in inshore waters, giving the recreational fishing community complete access to the resource.

Georgia has no commercial pound netting or haul seining, and gillnetting is prohibited except for shad and sturgeon during the open season for these species. Furthermore, only shad or sturgeon may be kept during gillnetting activities, and any other species captured must be immediately released unharmed. Considering the absence of competition from commercial interests, Georgia's recreational hook and line fishermen literally have their cake and are able to eat it too.

Georgia's offshore recreational fishing is focused primarily around nine artificial reefs constructed in the early 1970's, around the scattered patches of "live bottom" areas such as the Gray's Reef National Marine Sanctuary off Sapelo Island, and those patches farther offshore from Savannah, St. Catherines Island and Brunswick. Those fishermen with larger offshore fishing boats quite often venture out to the Gulf Stream approximately 80 miles offshore. Both demersal groundfishes and migratory pelagics occur in fair numbers in offshore waters along Georgia's coast. Dominant offshore bottom fishes include seabasses, snappers, groupers, porgies, grunts and sheepsheads, and major pelagic species include bluefish, king and Spanish mackerel, cobia, greater amberjack, dolphin, Atlantic sailfish, white and blue marlin, and swordfish.

The inshore recreational fishery is centered primarily in the sounds and major rivers during the warmer months and in the rivers and creeks during the colder months. Surf fishing is limited, and takes place almost exclusively during warm months and during fair weather, and most of the prime surf fishing areas are accessible only by boat.

Most inshore fishing effort is directed toward sciaenid fishes with most effort focused on the spotted seatrout. Other fishes actively pursued include red and black drum, flounders, kingfish or "whiting", croakers, sheepshead, and bluefish. Generally, spots are relatively small and very little effort is directed toward them.

Excellent opportunities are afforded the Georgia inshore angler as there are currently no saltwater license fees, no creel or size limits, and the fish are comparable in size with those of other states. State records comparing Georgia fish with record fish from other states are presented in Table 1. The particular fish species being sought and the specific method employed to capture them changes seasonally, but good inshore fishing can generally be found throughout the year. The primary techniques employed by Georgia anglers and the baits used to catch each species are presented in Table 2.

Although there is no legal gillnet fishery in Georgia other than for shad and sturgeon, a variety of fish are landed and sold annually by other methods. Many groundfish are sold as by-catch from commercial shrimp fishing operations. This by-catch consists primarily of flounders, weakfish or "summer trout", kingfish or "whiting", croakers and spots. However, two of the most popular sportfish species, spotted seatrout and red drum, are rarely taken by trawlers. In addition to by-catch sales many fish are caught and sold annually by hook and line fishermen possessing personal commercial fishing licenses and who elect to sell all or a portion of their catches. The spotted seatrout is the primary target of inshore anglers and is consequently the species most frequently sold by hook and line fishermen. However, most other species are sold as well. Although Georgia's commercial finfish landings records are not recorded by commercial gear type, annual commercial landings of the major inshore recreational species since 1960 are presented in Table 3.

Table 1. Current state records for the 10 target species of fish as reported in pounds and ounces from the states where records were available.

	Spotted seatrout		Weak-fish		Red Drum		Southern Flounder		Summer Flounder		Black Drum		Sheeps-head		Atlantic croaker		Spot		Northern Kingfish		Southern Kingfish		Gulf Kingfish	
	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz	Lb	Oz
Rhode Island	-	-	-	-	-	-	-	-	17	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New York	-	-	17	14	-	-	-	-	22	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Jersey	11	2	17	8	51	9	-	-	19	12	102	12	-	-	5	8	-	-	-	-	-	-	-	-
Delaware	-	-	16	10	75	0	-	-	17	15	115	0	-	-	5	4	-	-	4	0	-	-	-	-
Maryland	16	8	16	8	74	6	-	-	17	0	103	8	-	-	6	3	2	0	2	8	-	-	-	-
Virginia	16	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Carolina	12	4	14	14	90	0	-	-	20	8	84	0	16	8	5	0	1	11	3	8	-	-	-	-
South Carolina	11	13	11	13	75	0	17	6	3	8	89	0	15	4	4	9	1	1	-	-	2	10	-	-
Georgia	9	7	6	8	45	0	15	2	-	-	81	0	13	3	5	12	-	-	-	-	2	12	-	-
Alabama	12	4	-	-	43	0	*13 3 (composite)				26	4	9	7	-	-	-	-	*2 8 (composite)					
Mississippi	10	6	-	-	44	0	*9 8 (composite)				42	0	10	4	-	-	-	-	*1 11 (composite)					
Louisiana	12	6	-	-	56	8	*12 2 (composite)				77	0	14	12	8	0	-	-	-	-	-	-	-	-

NOTE: A dash (-) denotes incomplete or unavailable records.
An asterisk (*) denotes a composite of two or more species.

Table 2. Ranking of the use of different types of fishing gear and baits used by saltwater anglers by season for each species of fish. (W= Winter; Sp= Spring; Su= Summer; F= Fall).

SPECIES	Use Rating	TERMINAL GEAR 1/ Bottom Rig	2/ Float Rig	3/Artificial Lure	BAIT TYPE Live Shrimp	Dead Shrimp	Minnows and fish	Cut bait (fish)	Crab and fiddlers	Oysters and clams	Squid
Spotted seatrout	Primary		Sp,Su,F	W,Sp	Sp,Su,F			*	*	*	*
	Secondary	Sp,Su,F	W	Su,F	W	Su,F	Sp,Su,F	*	*	*	*
Weakfish	Primary	W,Sp,Su,F		W,Sp		W,Sp,Su,F		*	*	*	*
	Secondary		W,Sp,Su,F		Sp,Su,F		Sp,Su,F	*	*	*	*
Red drum (Juvenile)	Primary		Sp,Su,F		Sp,Su,F	Sp,Su,F					
	Secondary	Sp,Su,F		F,W,Sp			S,F	Sp,Su,F	Sp,Su,F	Su,F	Su,F
Red drum (Bulls)	Primary	Sp,Su,F	*					Sp,Su,F	Sp,Su,F		
	Secondary		*	Sp,Su,F		Sp,Su,F	Sp,Su,F			Sp,Su,F	Sp,Su,F
Southern flounder	Primary	Sp,Su,F	Su,F		Su,F		Sp,Su,F	*	*	*	*
	Secondary			F,W		Su,F		*	*	*	*
Summer flounder	Primary	Sp,Su,F	Su,F				Sp,Su,F	*	*	*	*
	Secondary			F	Su,F	Su,F		*	*	*	*
Black drum (Juvenile)	Primary	Sp,Su,F		*		Sp,Su,F	*	*	Sp,Su,F		*
	Secondary		Sp,Su,F	*	Sp,Su,F		*	*		Sp,Su,F	*
Black drum (Bulls)	Primary	Sp,Su,F		*			*	*		Sp,Su,F	*
	Secondary		Sp,Su,F	*	Sp	Sp	*	*	Sp,Su,F		*
Sheepshead	Primary	Sp,Su,F		*			*	*	Sp,Su,F	Sp,Su,F	*
	Secondary		Sp,Su,F	*	Sp,Su,F	Sp,Su,F	*	*			*
Atlantic croaker	Primary	Sp,Su,F		*		Sp,Su,F	*	*		*	*
	Secondary		Sp,Su,F	*	Sp,Su,F		*	*	Sp,Su,F	*	*
Spot	Primary	Sp,Su,F	*	*	*	Sp,Su,F	*	*			
	Secondary		*	*	*		*	*	Sp,Su,F	Sp,Su,F	Sp,Su,F
Southern kingfish	Primary	Sp,Su,F	*	*		Sp,Su,F	*	*			*
	Secondary		*	*	Sp,Su,F		*	*	Sp,Su,F	Sp,Su,F	*

1/ Conventional surf or bottom rig.

2/ Adjustable depth float rig.

3/ Lures, bucktails and plastic tail jigs.

* This technique is seldom used by Georgia anglers.

Table 3. Commercial landings for Georgia's major inshore recreational fisheries in thousands of pounds and thousands of dollars from 1960 through 1982.

Year	Spotted Seatrout		Weakfish		Red Drum		Flounder Composite		Black Drum		Sheepshead		Atlantic Croaker		Spot		Kingfish (Whiting)	
	lb.	$	lb.	$	lb.	$	lb.	$	lb.	$	lb.	$	lb.	$	lb.	$	lb.	$
1960	(1)	(1) 1/	-	- 2/	(1)	(1)	39	4	3	(1)	-	-	(1)	(1)	(1)	(1)	282	23
1961	2	1	-	-	1	(1)	37	4	1	(1)	-	-	-	-	(1)	(1)	247	20
1962	1	(1)	-	-	-	-	27	3	-	-	-	-	1	(1)	4	(1)	166	13
1963	5	2	(1)	(1)	-	-	22	3	1	(1)	-	-	1	(1)	4	1	125	11
1964	2	1	-	-	-	-	6	(1)	1	(1)	(1)	(1)	(1)	(1)	3	(1)	91	9
1965	9	3	2	(1)	-	-	51	5	2	(1)	1	(1)	2	(1)	11	1	253	28
1966	3	1	1	(1)	3	(1)	35	6	1	(1)	1	(1)	5	1	5	1	146	19
1967	7	2	(1)	(1)	6	1	22	4	2	(1)	1	(1)	6	(1)	11	1	187	19
1968	2	1	(1)	(1)	6	1	23	5	1	(1)	(1)	(1)	-	-	2	(1)	123	15
1969	3	1	1	(1)	3	1	28	5	(1)	(1)	(1)	(1)	2	(1)	2	(1)	111	13
1970	10	2	(1)	(1)	2	(1)	37	6	7	1	1	(1)	9	(1)	9	1	146	15
1971	16	4	-	-	1	(1)	51	9	(1)	(1)	1	(1)	(1)	(1)	6	1	165	19
1972	26	6	-	-	3	1	63	13	2	(1)	1	(1)	2	(1)	33	3	200	25
1973	27	10	(1)	(1)	4	1	77	18	5	1	5	1	15	1	34	4	217	33
1974	16	6	-	-	3	1	74	16	3	1	7	1	8	1	16	2	190	30
1975	31	13	2	(1)	10	1	90	24	4	1	6	1	4	1	9	1	222	41
1976	30	15	-	-	7	2	113	35	2	1	6	1	14	2	18	3	227	48
1977	16	9	1	(1)	5	2	82	28	1	(1)	(1)	(1)	7	2	7	1	162	38
1978	2	1	(1)	(1)	(1)	(1)	96	41	-	-	-	-	(1)	(1)	(1)	(1)	282	62
1979	5	4	1	(1)	(1)	(1)	112	49	-	-	-	-	19	6	(1)	(1)	171	54
1980	4	3	(1)	(1)	(1)	(1)	76	33	1	(1)	1	(1)	5	1	1	(1)	235	79
1981	(1)	(1)	(1)	(1)	(1)	(1)	56	28	(1)	(1)	(1)	(1)	1	(1)	8	3	202	85
1982	5	5	1	(1)	(1)	(1)	80	34	-	-	(1)	(1)	2	1	(1)	(1)	381	151

1/ Parentheses indicate less than 500 lb. or $500.

2/ A dash (-) indicates none reported.

NOTE: Commercial landings include species caught and sold by recreational anglers.

With the current population expansion along the coast and its accompanying demand on the finfish stocks now and in the future, fishery managers need technical information on the life histories of these sportfishes to facilitate proper management decisions for regulating the harvest. In order to gain much needed baseline data on the inshore fishery the Georgia Department of Natural Resources initiated this study in July 1978 to analyze certain life history aspects of the 11 major species caught by Georgia's inshore anglers. Data were collected on movement and migration, age and growth, feeding habits, maturity and spawning as well as other information related to Georgia's inshore sportfishery as it exists today. The local names, accepted common names and scientific names of these inshore sportfish targeted for study appear in Table 4. Information is presented in this paper to be of benefit to anglers and laymen as well as to fishery managers and the scientific community.

Table 4. List of scientific and accepted common names approved by the American Fisheries Society plus local names used by Georgia anglers for fishes investigated in Georgia from January 1979 through June 1982.

SCIENTIFIC NAME	ACCEPTED COMMON NAME	LOCAL NAMES
Cynoscion nebulosus (Cuvier)	Spotted seatrout	*Trout Spotted trout Winter trout Speckled trout **Gator trout
Cynoscion regalis (Bloch and Schneider)	Weakfish	*Summer trout Yellowmouth trout
Sciaenops ocellatus (Linnaeus)	Red drum	*Bass Channel bass Spot-tail bass School bass Red drum Red bass **Stag bass
Pogonias cromis (Linnaeus)	Black drum	*Drum Black drum Puppy drum
Micropogonias undulatus (Linnaeus)	Atlantic croaker	Croaker **Virginia croaker
Menticirrhus americanus (Linnaeus)	Southern kingfish	*Whiting **Bull whiting
Menticirrhus littoralis (Holbrook)	Gulf kingfish	*Beach whiting Silver whiting
Leiostomus xanthurus Lacepède	Spot	Spot
Paralichthys lethostigma Jordan and Gilbert	Southern flounder	*Flounder Winter flounder
Paralichthys dentatus (Linnaeus)	Summer flounder	*Flounder Summer flounder
Archosargus probatocephalus (Walbaum)	Sheepshead	Sheepshead

* Most commonly used local name.

** Term used for large specimens.

METHODS AND MATERIALS

The coastal area of Glynn County lies within the western-most portion of the South Atlantic bight (Figure 1). Glynn County is in the center of the Georgia coast and is typical of the entire Georgia coast in that it has a four to six mile expanse of marshland separating the mainland from the outer barrier islands. This band of marshland comprises approximately 159 thousand hectares (393 thousand acres) with nearly 116 thousand hectares (286 thousand acres) covered by a single species of marsh grass, known as saltmarsh or smooth cordgrass, *Spartina alterniflora* Loisel (Spinner, 1969). The coastal marshes are subjected twice daily to tides of approximately the same height, normally ranging from 1.8 to 2.4 meters (6 to 8 feet). Greatest tidal amplitude occurs during the fall when tides often reach or exceed 3 meters (9 feet). The grain size of sediments in the marsh range from clay to fine sand, and the marsh soils are normally neutral to slightly alkaline (Johnson et al.,1974).

The study area was divided into four sectors for comparative purposes. The four sectors included: 1) creek sector, consisting of the smaller creeks and rivers usually located in the upper portion of the estuary; 2) sound sector, consisting of the sound and adjacent major rivers; 3) beach sector, consisting of the beaches and outer bars and shoals, and 4) offshore sector, consisting of offshore waters beyond the outer bars. Sampling in the offshore sector was limited to collection of specimens for age and reproduction analyses.

The fish collected for tagging and laboratory analyses were captured through the use of gill nets, trammel nets, seines, traps, cast nets, trawls, spear guns and conventional hook and line gear. The various mesh sizes of net types utilized are listed in Table 5.

Fish collected for tagging were taken directly from the nets and placed in a holding bag suspended in ambient water (Figures 2 and 3). Before tagging, all fish were individually inspected for injuries, and

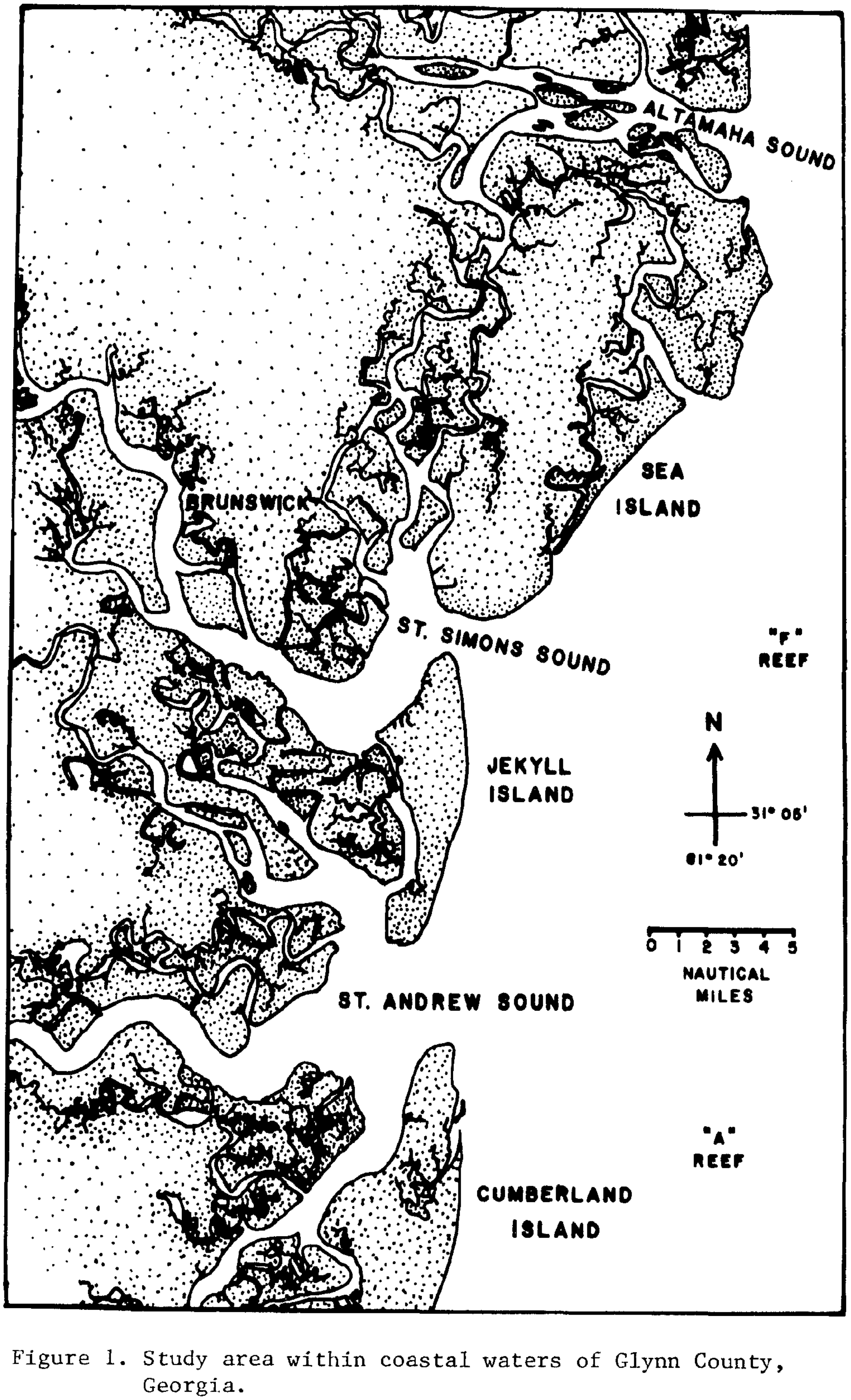


Figure 1. Study area within coastal waters of Glynn County, Georgia.

Table 5. Description of net types.

Gear Type	Gear Specifications
Gill Net (1½ in.)	Stretched mesh, 1½ in.; meshes deep, 50; twine, #139 monofilament; net length, 10 yd.; leadline, 50 lb. Samson; floatline, ½ in. polyethylene corkline.
Gill Net (2 in.)	Stretched mesh, 2 in.; meshes deep, 40; twine, #177 monofilament; net length, 35 yd.; leadline, 50 lb. Samson; floatline, ½ in. polyethylene corkline.
Gill Net (2-7/8 in.)	Stretched mesh, 2-7/8 in.; meshes deep, 50; twine, #208 monofilament; net length, 200 yd.; leadline, 75 lb. Dura; floatline, 2-3/8 in. polyfoam floats on 3/8 in. polyethylene line.
Gill net (3½ in.)	Stretched mesh, 3½ in.; meshes deep, 25; twine, #208 monofilament; net length, 165 yd.; leadline, 85 lb. Dura; floatline, ½ in. polyethylene corkline.
Gill Net (4-5/8 in.)	Stretched mesh, 4-5/8 in.; meshes deep, 35; twine, #208 monofilament; net length, 200 yd.; leadline, 85 lb. Dura; floatline, 3 in. polyfoam floats on 3/8 in. polyethylene line.
Trammel Net	Stretched mesh, 2 in. inner panel and 8 in. outer panels; meshes deep, 60 inner panel and 8 outer panel; twine, #209 nylon inner panel and #9 nylon outer panel; net length, 100 yd.; leadline, 75 lb. Samson; floatline, #125 plastic floats (1 x 4 in.).
Trawl	One 40 ft. flat otter trawl with 1-7/8 in. stretched mesh webbing and 1-3/4 in. stretched mesh bag with 48 in. doors.
Trawl	One 10 ft. flat otter trawl with 1¼ in. stretched mesh webbing and 1¼ in. stretched mesh bag with 30 in. doors.
Cast Net	Seven foot with 2 in. stretched mesh webbing.
Cast Net	Six foot with 1 in. stretched mesh webbing.
Seine (1/8 in.)	Mesh, 1/8 in. braided with nylon twine; net length, 12 ft.; net depth, 4 ft.
Seine (1½ in.)	Stretched mesh, 1½ in.; meshes deep, 50; twine, #208 monofilament; net length, 33 yd.

Figure 2. Gillnetting activities.

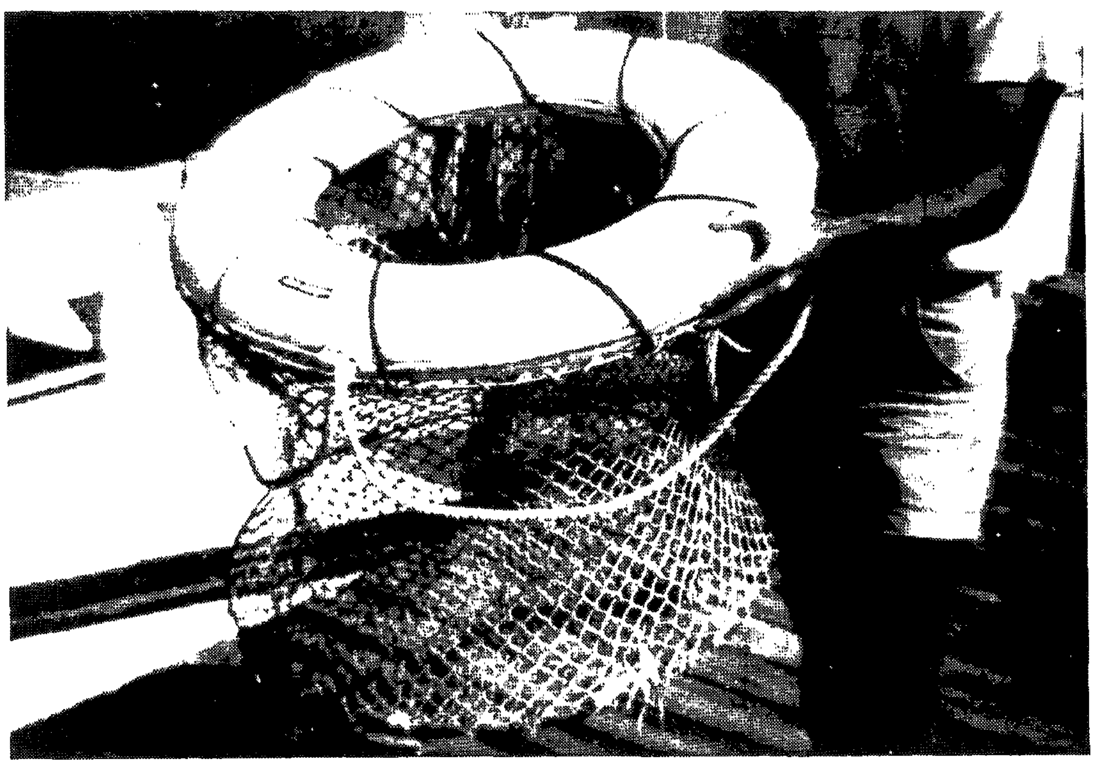


Figure 3. Fish "holding bag" showing float with suspended net.

only active, apparently unharmed fish were measured and tagged. Most creel size specimens were tagged with internal anchor tags manufactured by the Howitt Plastics Company of Molalla, Oregon. Small fish (<160 mm) were tagged with Floy FD-68BC internal anchor tags manufactured by Floy Tag and Manufacturing, Inc. of Seattle, Washington. A total of 116 creel size fish were double tagged with both Howitt and Floy tag types in order to make tag retention comparisons. Tagged fish were released in the area of capture.

The internal anchor portion of the Howitt tags were oval plastic disks measuring 6 x 25 x 0.8 mm (.25 X 1 X .03 in.) with a 1.9 mm (0.76 in.) hole in the center of the disk. The streamer portion of the tag was constructed from 2 mm diameter vinyl spaghetti tubing cut in 75 mm lengths. Streamers were heated on one end and flattened to form a nailhead shape. The streamer was then passed through the hole in the tag disk and locked in place (Figure 4). Each tag in the first set of 5,000 tag disks was marked on both sides. One side was marked: "REWARD, SEND TAG, DATE, EXACT LOCATION, LENGTH, HOW CAUGHT AND BAIT USED TO:", and the other with "COASTAL RESOURCES DIVISION, 1200 GLYNN AVENUE, BRUNSWICK, GEORGIA 31523" and included the tag serial number. Each tag in the second set of 5,000 tag disks was marked identically to first set except "LENGTH" was deleted and "PHONE" added. This change was made because many of the lengths reported by those catching tagged fish were reported as approximate or estimated lengths which could not be used for growth measurement. Telephone numbers were included to obtain more accurate information than was reported from tags returned in the mail.

Insertion of the Howitt tag was accomplished by making a small incision, approximately 8 mm in length, through the ventral musculature of the abdominal wall midway between the left pelvic fin and anal vent (Figure 5). The tag disk was inserted lengthwise into the body cavity with the streamer portion protruding from the ventral body wall (Beaumariage and Wittich, 1966; Bruger, 1981). For small fish approximately 225 mm or less in length, the Howitt streamer was shortened to approximately 50 mm.

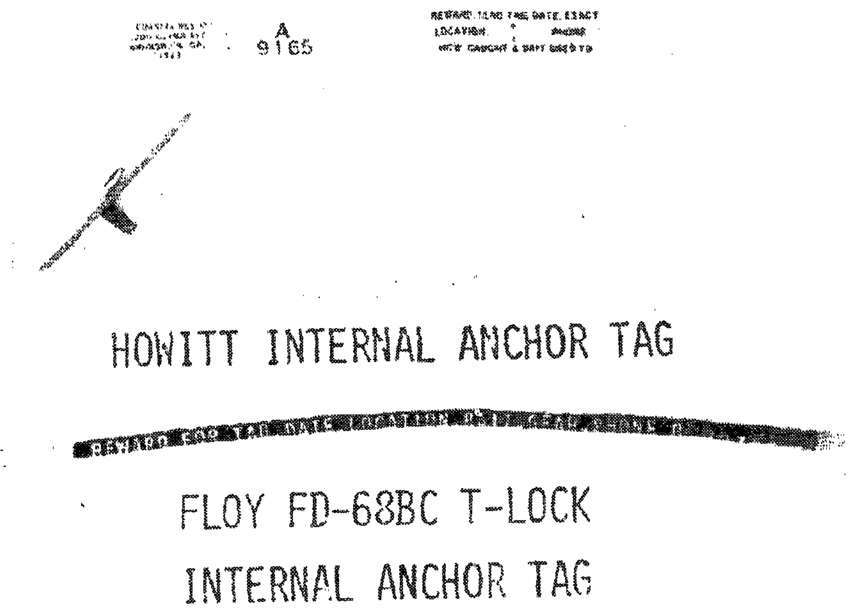


Figure 4. The Howitt and Floy internal anchor tags.

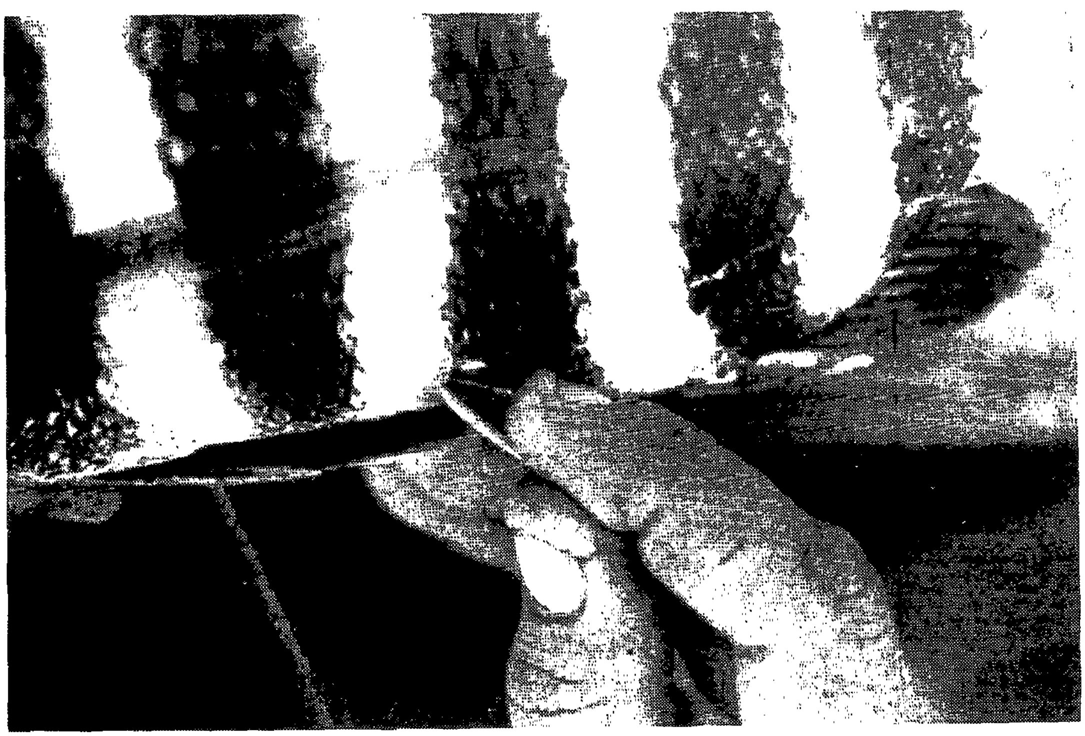


Figure 5. Insertion of the disk portion of the Howitt tag was accomplished by making a small incision through the ventral musculature of the abdominal wall and inserting the disk lengthwise into the body cavity.

Floy FD-68BC, T-lock internal anchor tags were comprised of #20 size tubes with monofilament inserted through and secured. The dimensions of the tags were 105 mm overall with a tube length and diameter of 70 and 1.8 mm, respectively (Figure 4). A total of 4,000 Floy tags were divided into three color groups: 2,000 orange, 1,000 green and 1,000 blue. The tube portion of the Floy tag was marked on both sides; one with "REWARD FOR TAG, DATE, LOCATION, BAIT, GEAR" and the other with "MAIL TO DEPARTMENT OF NATURAL RESOURCES, 1200 GLYNN AVENUE, BRUNSWICK, GEORGIA" and included the tag serial number. The Floy FDM-68 tagging gun with stainless steel needle, cutter bar and ram was used to insert tags. The tagging needle was inserted to a maximum depth of 27 mm. Floy tags were inserted on the dorsal left side of the fish just below the dorsal fin (Figure 6). The T-lock portion was inserted between the interneural spines (Pterygiophores) to insure that the locking portion was firmly in place. Figures 7 and 8 show the location and position of both internal tag types attached to fish.

The tagging process was begun immediately after all fish were removed from the nets and the following information was recorded: year, date, location, salinity, water temperature, barometric pressure, tidal stage, moon phase, gear type, bait, tag number, and total length of each fish. A random sample of the targeted species caught plus any injured fish were placed on ice and transported to the laboratory for ageing, reproduction and food preference studies. Surface water salinity was measured with an American Optical refractometer and surface water temperature was measured with an immersion thermometer. Fish length was measured to the nearest millimeter. Total lengths of fish possessing rounded caudal fins were measured from the tip of the head to the end of the longest median rays. Natural tip total lengths (NTL) were taken for sheepshead and spot and defined by Ricker and Merriman (1945) as the length from the tip of the head to the posterior edge of either lobe of the fork tail, whichever is longer, when lying in a natural position. The fork length was defined by Ricker and Merriman (1945) as the length which lies on a continuation of the line formed by the posterior half of the main vertebral axis from

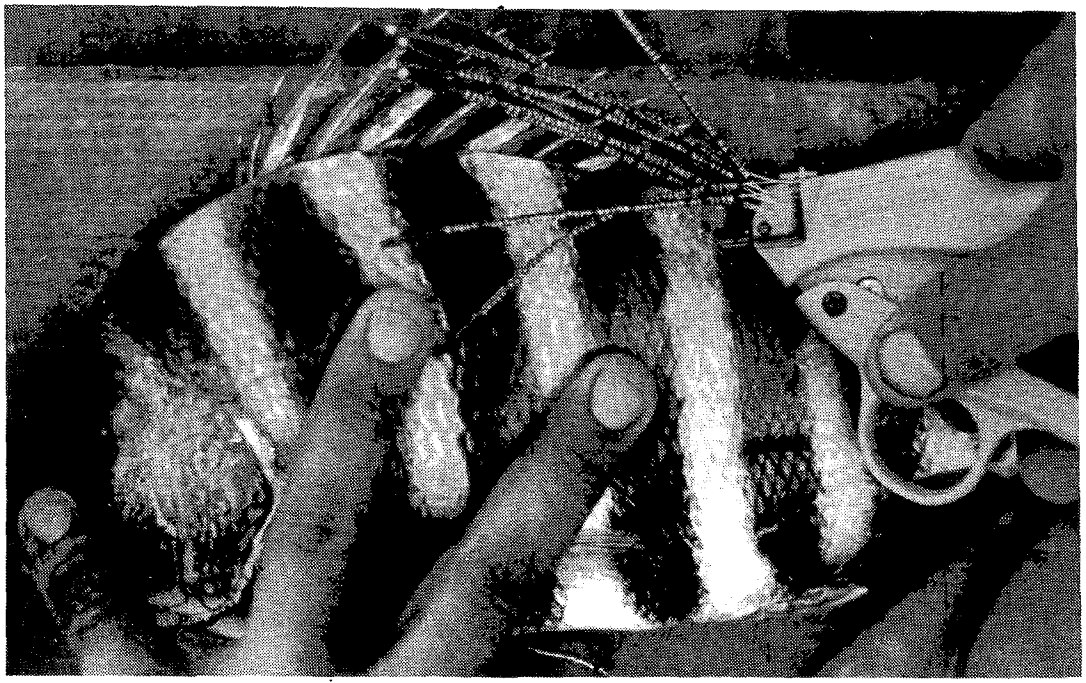


Figure 6. Floy tags were inserted on the left side just below the posterior portion of the dorsal fin.

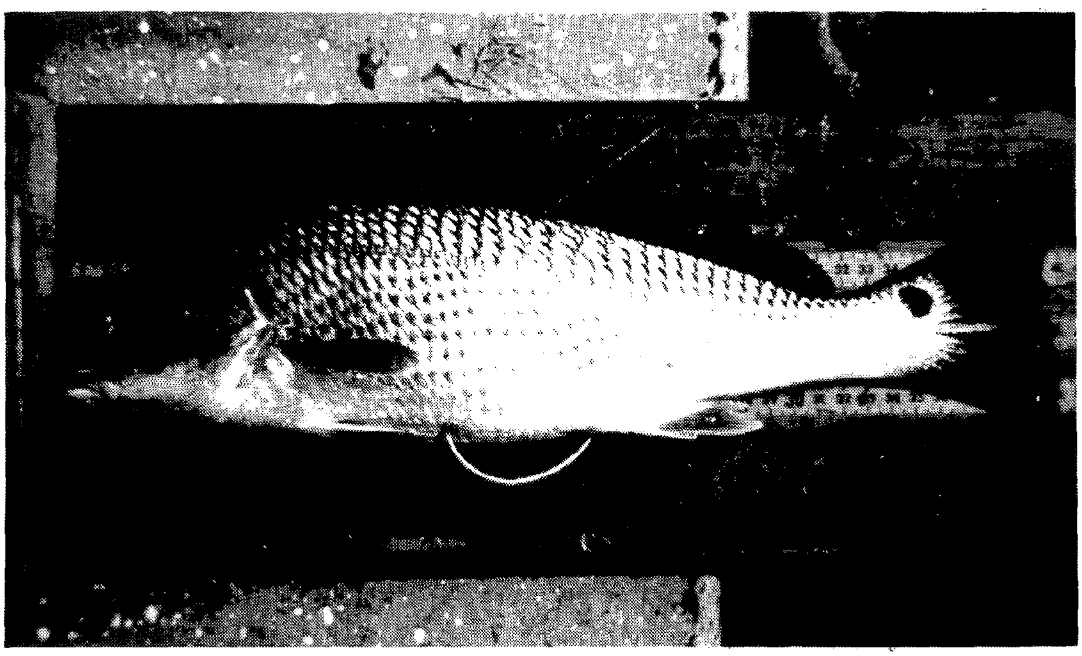


Figure 7. A double-tagged red drum showing typical appearance of tag streamers.

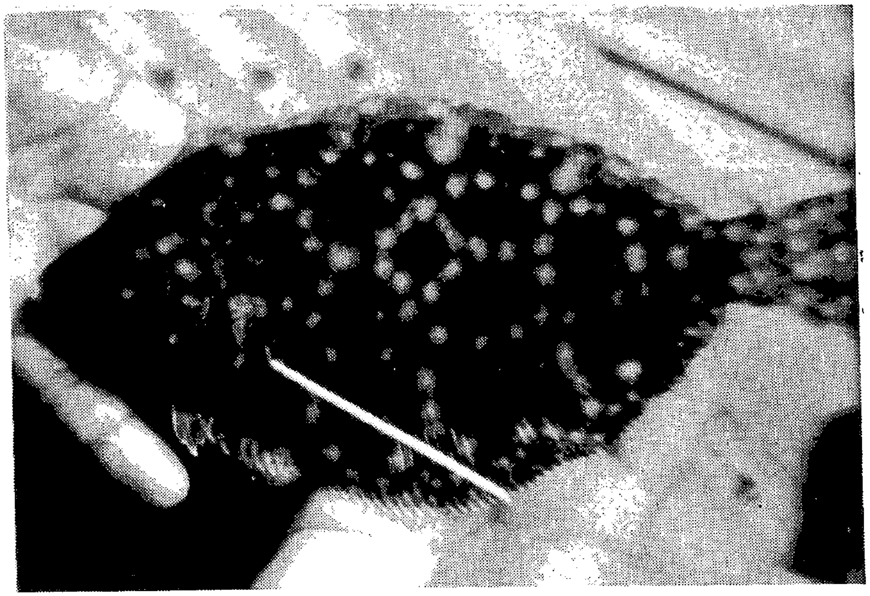


Figure 8. A tagged flounder showing typical appearance of Howitt streamer.

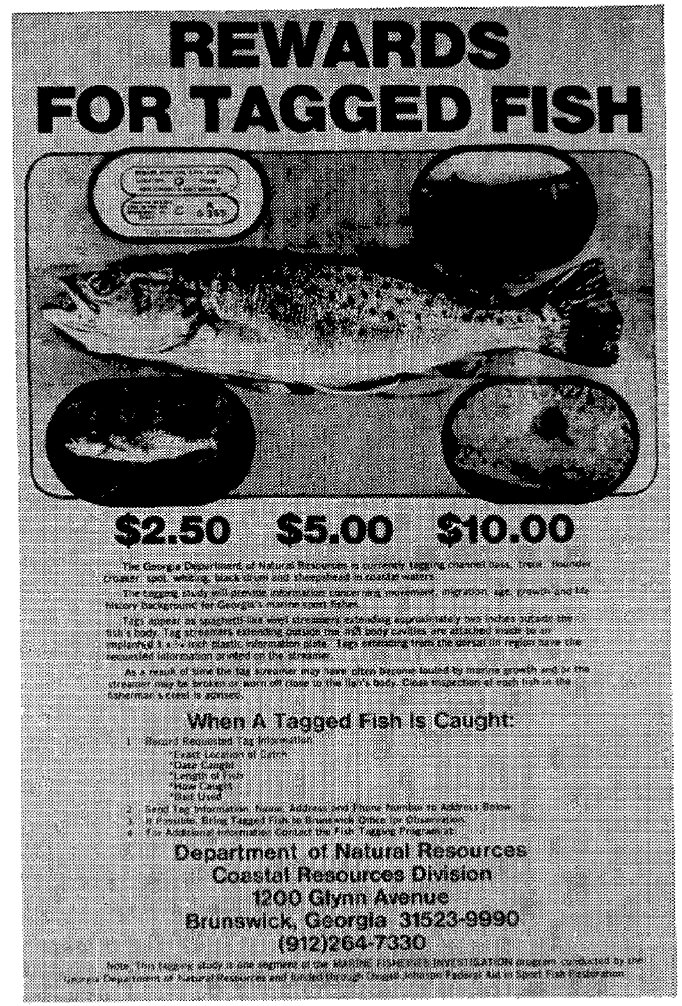


Figure 9. Tag reward poster distributed throughout coastal counties to publicize tagging studies.

the tip of the head to the middle of the fork of the caudal fin. Unless stated otherwise, all lengths are total length measurements.

Information recorded upon recapture included tag number, location and date of recapture, gear type, and bait used. Also, the fisherman's address and phone number were obtained in order to send a reward, letter of appreciation, and release information concerning the recaptured fish. When available, length, sex, and tag streamer conditions were recorded.

Initial tag reward values of $1.00, $5.00 and $10.00 were assigned through a restricted randomized system developed by North Carolina State University's Institute of Statistics. The $1.00 rewards were increased to $2.50 after the first year in hopes of higher return rates. As of September 9, 1983, a total of $1,833.50 had been paid to fishermen for tag rewards. Publicity for the tagging study was accomplished through news releases in coastal counties, through talks to civic and sportfishing clubs, and through distribution of tag reward posters at sporting goods stores, marinas, docks and launching sites (Figure 9).

Fish collected for laboratory dissection were immediately placed on ice for approximately 4 to 18 hours prior to processing. Pafford (1983) determined the shrinkage of striped mullet (250 to 290 mm) after 18 hours on ice was 1.3 percent of the total length of the live fish. Therefore, percent of shrinkage was considered insignificant. Environmental parameters and gear data recorded during the tagging activities were also recorded for fish sacrificed for laboratory analyses. Fish captured for laboratory analyses were weighed and measured; the stomachs, otoliths, and scales were removed; and the sexes, stages of gonadal development, and fecundities were determined. All fish weighing over 100 g were weighed to the nearest gram, and specimens weighing 100 g or less were weighed to the nearest 0.1 g. In addition to natural tip total lengths, fork lengths (FL) were taken to the nearest millimeter on a random sample of 154 sheepshead (length range: 95 to 527 mm FL) and 100 spot (length range: 123 to 237 mm FL) for conversion purposes. To convert natural tip length to fork length, the conversion values of 0.94 for sheepshead and 0.95 for spot were determined to be applicable.

Length-weight relationships were fitted by the general parabola $A = aL^b$ (Ricker, 1975). The coefficients "a" and "b" were determined from regressing log A on log L.

Scale samples were taken from behind the left pectoral fin (Miller, 1966; Barger and Johnson, 1980). The sagittal otoliths were exposed to forcep removal by cutting and removing portions of the parasphenoid and prootic bones. The sacculus membrane was removed from each otolith. Upon removal, scale samples and otoliths from each fish were immediately placed together in labeled vials containing 70% ETOH for later processing and ageing. This prevented scale samples from drying and cracking before pressing.

Scale samples were taken directly from the alcohol, cleaned, and placed between labeled cellutose plastic sheets measuring 25 x 75 x 0.60 mm (Cellutone Plastics, Inc., New York, N.Y.). The scales were pressed at 80°C, 15,000 psi for 10 seconds in a Carver laboratory press (Fred S. Carver, Inc., Menomonee Falls, WI) as shown in Figure 10. Large scales (>20 mm dia.) were placed between 3 to 5 cellutose slides and pressed for approximately 1.5 minutes. After pressing, sample numbers were etched on the slides, and the scale impressions along with the otoliths were stored in labeled coin envelopes. Scale impressions were viewed under a binocular microscope at 40X magnification. For meticulous observations, the larger scale images were also viewed on an Eberback fish scale projector (Eberback Corporation, Ann Arbor, MI) at 48X magnification.

A minimum of two scales were examined from each fish for recurring circuli pattern comparisons to aid in ring or annuli identification. In general, these recurring patterns of closely spaced or sudden breaks in the pattern of circuli were considered to be "true" annuli or yearmarks (Klima and Tabb, 1959; Miller, 1966; Lux, 1971). Usually, the breaks in circuli can be identified from other incidental marks or false rings when several scales from the same fish are examined. Also, annuli may consist of straight circuli between radii, new circuli cutting over the incomplete circuli, and breaks or disconformities

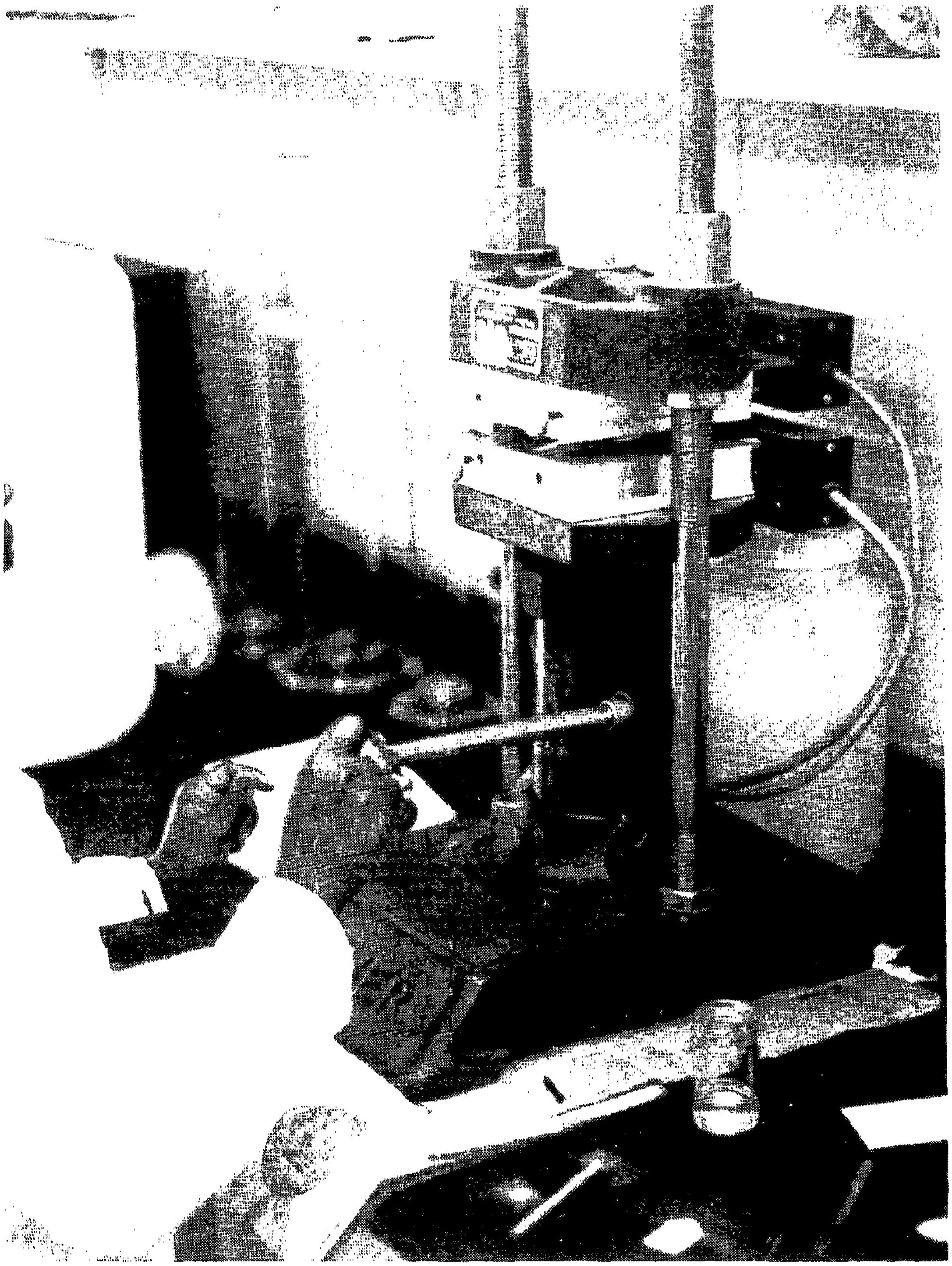


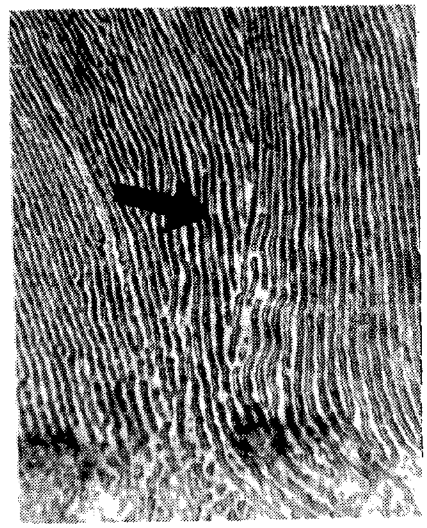
Figure 10. Carver laboratory press used to make scale impressions on cellutose plastic sheets.

in circuli forming completely around the lateral and anterior portions of the scale (Figure 11). Cutting over occurs where more recent circuli appear to cut across several other incomplete, older circuli in the lateral field. Scale increment measurements were made with an ocular micrometer in millimeter units. Increments were counted and measured diagonally from the focus to the edge of the scale (Klima and Tabb, 1959; Hofstede, 1974; Richards, 1973) (Figure 12).

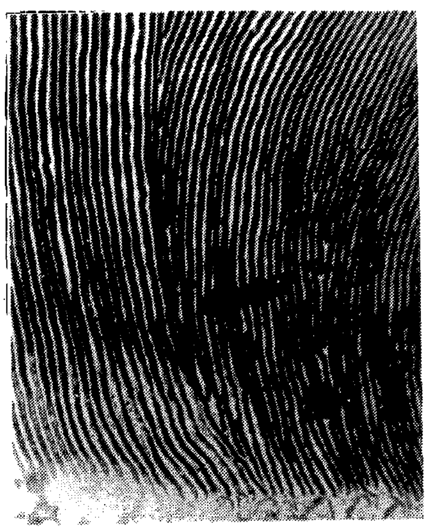
Otoliths were cleaned, dried, and stored with the scale impressions in open-end coin envelopes. For age determination, whole otoliths of southern and summer flounder, spot and sheepshead were immersed in a small black dish containing cedarwood oil and examined under reflected light (Lux, 1971; Williams and Bedford, 1974). Otoliths from these species were viewed under a microscope at 20X magnification. Otolith ring counts were made from the center of the core to the edge of the otoliths with the concave side up (Figure 13). Otoliths of spotted seatrout, weakfish, croaker, red and black drum and southern and gulf kingfish were cross-sectioned through the core into 0.45 mm (0.018 in.) wafer sections using an Isomet low speed saw (Buehler Ltd., Evanston, IL) with a 0.012 in. thick diamond-edge wafering blade (Figures 13 and 14). Due to the difficulty in handling, small otolith sections (<3 mm dia.) were mounted on labeled acetate slides for viewing. These were viewed at 40X magnification with transmitted light. Larger otolith sections were placed in cedarwood oil and viewed at 20X magnification. For ease of scale and otolith ring count comparisons, the hyaline zone was counted as the end of one year's growth (Lux, 1971; Bortone and Hollingsworth, 1980).

Otoliths and scales were examined twice. If the two counts did not agree, a third reading of the questionable structure was made. Disagreement after three readings precluded the use of the structure in age and growth analyses. Otoliths and scales from each fish were examined independently and compared for documentation of ageing methods. Errors most often arose by missing the first annulus or with closely spaced annuli of older fish.

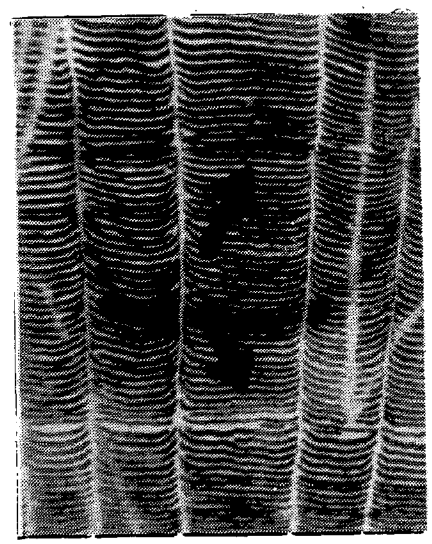
A. Spotted seatrout



B. Sheepshead



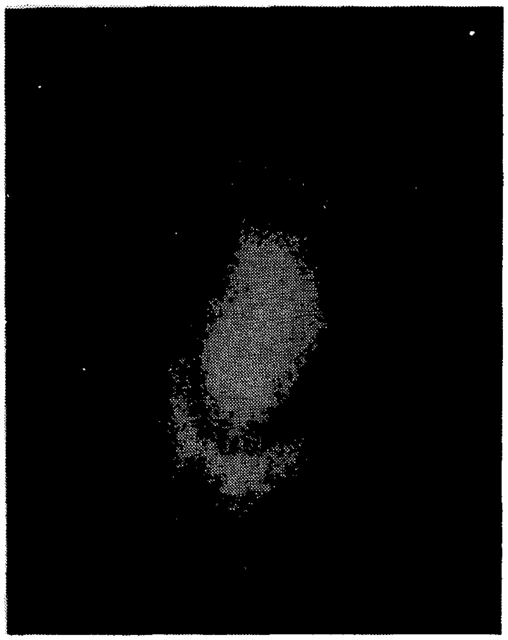
C. Black drum



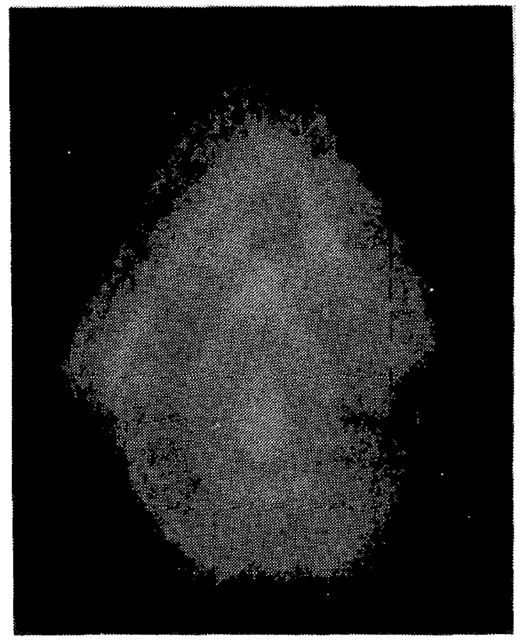
D. Atlantic croaker

Figure 11. Photographs A, B and C show formation of annulus by more recent circuli cutting over older circuli in the lateral portion of scales. Photograph D shows disconformities of circuli during formation of annulus.

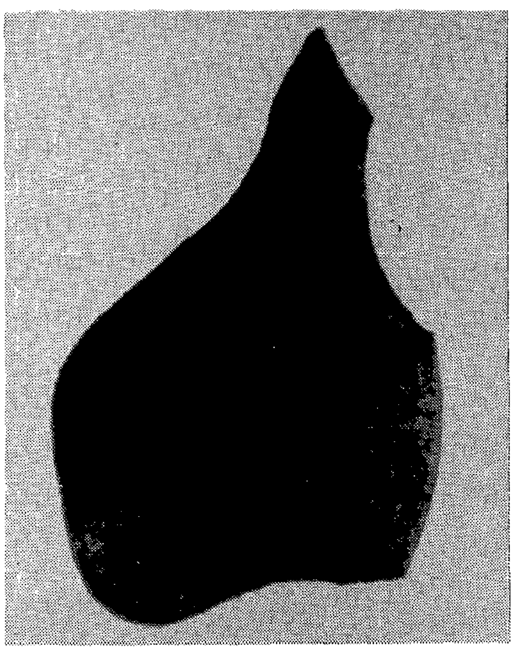
Figure 12. Scale of a two year old spotted seatrout. Roman numerals indicate annuli, "F" denotes focus, and marginal increment (MI) is from the last annulus to the edge of the scale. Solid line illustrates the direction of increment measurement.



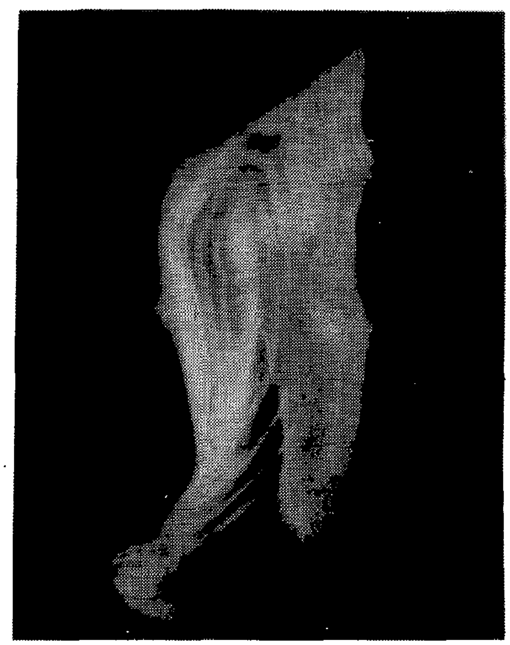
A. Spot



B. Southern flounder



C. Spotted seatrout



D. Black drum

Figure 13. Whole and sectioned otoliths as viewed with reflected and transmitted light. Otoliths A, B and D were illuminated from above and viewed against a dark background. Otolith C was illuminated from below by transmitted light.

Figure 14. Isomet low speed saw used to section otoliths.

The mean monthly growth of marginal increments on scales for each species was calculated by age to validate the time of annulus formation and the number of rings formed annually. Calculations were performed on all age groups; however, lack of sufficient monthly numbers of older age classes limited documentation of the time and number of increment formations necessary for ageing older specimens of red drum and black drum. To gain additional data to validate the number of increments formed annually, scale samples were taken from 104 red drum and 59 black drum at the time of release. Upon recapture scale samples were again taken and compared with scales taken at release.

To determine whether fish length/scale radius relationships were sufficiently linear to warrant direct proportion calculations, least-squares regression analyses were performed for each species. Relatively high r^2 values indicated relationships were significantly linear and that growth of the scales was isometric with growth of body length. Therefore, body lengths at time of annulus formation were back calculated with the use of the direct proportion formula $L' = \frac{S'}{S} \times L$ (Broadhead, 1958; Klima and Tabb, 1959; Smith, 1969). The lengths for each age were calculated as follows:

L' = the length of the fish when annulus ith was formed.

S' = the length of the scale radius to the ith annulus.

S = the total length of the scale radius.

L = the length of the fish when sampled.

Length-age relationships were fitted by the general parabola $A = aL^b$. The coefficients "a" and "b" were determined by regressing log A on log L.

Fish stomachs were removed and individually wrapped in cheesecloth with coded plastic identification labels and preserved in 10% buffered formalin solution. Stomachs were placed in Nalgene jars for later content identification.

Texas Instruments, Inc. (Dallas, Texas) was contracted to identify stomach contents of fish collected from January 1979 through May 1979. Project personnel identified stomach contents of all other fish examined.

Contents of each stomach were placed in glass bowls and examined under a binocular microscope at 10X magnification. Food items were identified to lowest possible classification. The number of stomachs examined for each species was dependent on the total number of specimens captured and the number of samples necessary to statistically validate conclusions drawn from stomach analyses.

To facilitate comparisons of stomach contents with food items available in the capture area, five minute trawl tows (using a three meter trawl with a 12.5 mm stretched mesh body and 6 mm knit mesh bag) and benthic samples (using a petite Ponar grab) were taken from January 1979 through June 1980 to capture available food items. In addition, 10 minute plankton net tows (using a ½ m diameter plankton net with 505 micron mesh) were made to capture the available food items during 1979. Texas Instruments, Inc., also identified the first five months of the plankton samples. Plankton sample identification was discontinued after the initial five month period.

The sexes and stages of gonadal development were classified through gross examination. Sex was determined as juvenile, female, or male. Gonad developmental stages were determined using Hjort's scale of maturities as a guide (Table 6). For clarity, maturity refers to the size at which sex could be determined through gross observation while spawning refers to fish with reproductively developing gonads preceding and including spawning.

Subsamples of stage V gonadal tissue were removed and the eggs counted and compared with whole gonads to determine fecundities. One gram segments were taken from the anterior, medial and posterior sections of both the left and right ovary. Egg counts from each segment were averaged to determine the mean number of eggs per gram. The fecundity was then determined by multiplying the mean by total ovary weight (Lehman, 1953; Street, 1969).

All data were coded and entered into the IBM 370 computer at the University of Georgia via the remote entry terminal at Coastal Resources Division, Brunswick, Georgia. Statistical analyses were conducted by the Statistical Analysis System (SAS) package of programs (Helwig and Council, 1979).

Table 6. Hjort's scale of maturities for classifying the reproductively developing states of sexual organs.

Reproductive Stage	Stage Description
I	Virgin individuals. Very small sexual organs close under vertebral column. Wine-colored torpedo-shaped ovaries about 2-3 cm long and 2-3 cm thick. Eggs invisible to the naked eye. Whitish or greyish brown knife-shaped testes 2-3 cm long and 2-3 cm broad.
II	Maturing virgins or recovering spents. Ovaries somewhat longer than half the length of the ventral cavity about 1 cm diameter. Eggs small but visible to naked eye. Milt whitish, somewhat bloodshot, same size as ovaries, but still thin and knife-shaped.
III	Sexual organs more swollen, occupying about half the ventral cavity.
IV	Ovaries and testes nearly filling 2/3 ventral cavity. Eggs not transparent, milt whitish swollen.
V	Sexual organs filling ventral cavity. Ovaries with some large transparent eggs. Milt white, not yet running.
VI	Roe and milt running (spawning).
VII	Spents. Ovaries slack with residual eggs. Testes baggy, bloodshot. Doubtful cases are indicated by quoting two stages e.g. "St. I-II, St. VII-II, etc."

NOTE: The scale was used only as a guide to general classification of maturity stages.

RESULTS AND DISCUSSION

SPOTTED SEATROUT

Spotted seatrout *(Cynoscion nebulosus)* range from Laguna Madre, Mexico to south Florida in the Gulf of Mexico and along the Atlantic coast from south Florida to New York (Fischer, 1978).

In Georgia, spotted seatrout are year-round estuarine inhabitants, moving in and out of the sounds with the changing seasons. In winter months they prefer the creeks and rivers where overwintering shrimp and juvenile fish are more abundant. During the cooler months, concentrations of spotted seatrout are found in areas of oyster reefs and in mouths of tidal creeks with shell and mud or sand bottoms. However, during spring and summer months they frequent sand bottom areas on beaches and near inlets. In general, spotted seatrout prefer shoreline habitat during all seasons of the year.

Movement and Migration

From January 16, 1979 through June 22, 1982, 3,381 spotted seatrout were tagged and released. Length frequencies of tagged seatrout in 50 mm length groups are included in Table 7. Seatrout tagged with Howitt internal anchor tags ranged in length from 175 to 655 mm and those tagged with Floy internal T-lock tags ranged 103 to 612 mm. Length frequencies of seatrout tagged with each tag type are shown in Table 8. Of 3,381 seatrout tagged, 35 were tagged with both tag types in order to compare and evaluate tag retention qualities. Table 9 lists the length frequencies of spotted seatrout collected for tagging in 20 mm groups by gear type.

Tagged spotted seatrout were returned from January 27, 1979 through July 1, 1983. Of 3,381 seatrout tagged, 456 (13.5%) were recaptured and tags returned. Recovery rates, when separated into 50 mm length groups, ranged as high as 17.6%. Information on the number of fish released and recaptured, time at large, and distance traveled are shown in Table 7. Time at large for spotted seatrout ranged from less than one day to 1,442

Table 7. Number tagged, number and percent recaptured, days at large and distance traveled for spotted seatrout, *Cynoscion nebulosus*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large		Distance Traveled (km) 1/	
				Avg.	Max.	Avg.	Max.
101 - 150	1	0	0.0				
151 - 200	5	0	0.0				
201 - 250	45	3	6.7	231	428	8.5	25
251 - 300	123	10	8.1	134	319	9.5	59
301 - 350	986	128	13.0	236	1,250	8.2	102
351 - 400	1,448	233	16.1	201	1,442	9.7	105
401 - 450	460	56	12.2	245	1,078	9.2	110
451 - 500	192	15	7.8	253	1,080	6.3	27
501 - 550	81	5	6.2	158	279	0.2	1
551 - 600	34	6	17.6	235	578	1.1	6
601 - 650	5	0	0.0				
651 - 700	1	0	0.0				
Total	3,381	456	13.5	216.9	1,442	8.9	110

1/ Distance measured in kilometers from point of release to point of recapture.

Table 8. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for spotted seatrout, *Cynoscion nebulosus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
125				1			1		
175	2			3			5		
225	42	3	7.1	3			45	3	6.7
275	102	10	9.8	20			122	10	8.2
325	857	126	14.7	124	2	1.6	981	128	13.0
375	1,270	227	17.9	162	3	1.9	1,432	230	16.1
425	366	56	15.3	84			450	56	12.4
475	119	13	10.9	71	2	2.8	190	15	7.9
525	66	5	7.6	14			80	5	6.3
575	25	6	24.0	9			34	6	17.6
625	4			1			5		
675	1						1		
Total	2,854	446	15.6	492	7	1.4	3,346	453	13.5

NOTE: Number tagged and recaptured does not include the 35 fish tagged with both tag types.

Table 9. Number of spotted seatrout, *Cynoscion nebulosus*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Gill Net (in)[1/]					Trammel Net	Trawl	Cast Net	Trap	Hook/Line	Totals
	2	2-7/8	3-1/2	4-5/8	6						
110	-	-	-	-	-	-	1	-	-	-	1
130	-	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	1	-	-	-	1
170	-	-	-	-	-	-	2	-	-	-	2
190	-	-	-	-	-	-	1	-	-	1	2
210	1	3	-	-	-	-	3	-	-	3	10
230	-	3	-	-	-	2	5	-	-	8	18
250	-	4	-	-	-	2	9	-	-	17	32
270	3	6	-	-	-	6	4	-	-	26	45
290	6	28	-	-	-	1	3	-	-	25	63
310	8	130	-	1	-	7	2	-	-	20	168
330	2	373	2	4	-	68	-	-	-	38	487
350	1	559	5	8	1	91	-	1	1	43	710
370	3	463	5	6	-	136	1	1	-	13	628
390	4	299	11	1	-	110	-	1	-	15	441
410	-	171	8	2	-	37	-	1	-	3	222
430	1	124	13	2	-	36	1	-	-	1	178
450	1	64	15	4	-	22	-	1	-	-	107
470	-	46	16	2	-	26	-	-	-	3	93
490	-	37	8	3	-	3	-	-	-	1	52
510	-	26	3	5	-	8	-	-	-	-	42
530	-	18	1	4	-	2	-	-	-	-	25
550	-	16	-	2	-	5	-	-	-	-	24
570	-	11	-	5	-	-	-	-	-	-	16
590	-	3	-	5	-	-	-	-	-	-	8
610	-	1	-	3	-	-	-	-	-	-	4
630	-	1	-	-	-	-	-	-	-	-	1
650	-	1	-	-	-	-	-	-	-	-	1
Totals	30	2,387	88	57	1	562	33	5	1	217	3,381

[1/]Gill net sizes are stretch mesh measurements.

days with an average at large time of 216.9 days. Distance traveled ranged as far as 110 km with an average of 8.9 km.

Analyses of returns by tag type revealed the overall recovery rate was 15.6% for seatrout tagged with Howitt tags and only 1.4% with Floy tags (Table 8). Also, recovery rates when separated into 50 mm length groups, ranged as high as 24.0% with Howitt tags and only 2.8% with Floy tags. Of 35 seatrout tagged with both tag types, only three were recovered. These three fish were at large from 97 to 249 days and only Howitt tags were attached when recaptured. In general, our recovery data indicate the Howitt internal disk tags are more reliable than Floy FD-68BC tags for long-term tagging studies. However, smaller fish can be tagged and multiple recaptures can be made with Floy tags. A disadvantage of the Howitt tag is that most fish must be killed to retrieve the tag. Return rates indicate that seatrout released during the fall produced the highest survival for both tag types (Table 10).

Recreational fishermen were the major source of seatrout recoveries, with 310 (68%) of the 456 returns. Only 4 (0.9%) returns were by commercial fishermen while study activities accounted for the remaining 142 (31.1%) recoveries (Table 11). Of the 310 recreational recaptures, 213 (69%) included sufficient information to determine lengths of creel size fish. Lengths (TL) of recreational recaptures ranged from 268 to 735 mm with an average size of 414 mm (Table 12). In general, length frequencies of recaptured seatrout indicated most creel size fish ranged from 350 to 500 mm with the greatest percentage of recoveries between 350 and 400 mm (Table 13).

Sufficient information was obtained on 446 (98%) recaptured fish to determine the estuarine sector location and season of recapture. The creeks produced the highest return rate with 65.5% of all recaptures (Table 14). This percentage was proportionally higher than the percentage of trout that were released in this sector (41.7%). This higher recovery rate may indicate several possibilities: 1) seatrout may remain longer in the creeks than in the other sectors, thus a greater chance of recapture, 2) greater fishing pressure in the creeks, and/or 3) most seatrout

Table 10. Number tagged and number and percent recaptured by species, tag type and season of release.

Species	Tag Type	Winter Tagged	Winter Returned	Winter Percent	Spring Tagged	Spring Returned	Spring Percent	Summer Tagged	Summer Returned	Summer Percent	Fall Tagged	Fall Returned	Fall Percent	Combined Tagged	Combined Returned	Combined Percent
Spotted seatrout	Howitt	1,332	198	14.9	443	62	14.0	227	29	12.8	852	157	18.4	2,854	446	15.6
	Floy	245	2	0.8	238	4	1.7	0	0	0.0	9	1	11.1	492	7	1.4
	Combined	1,577	200	12.7	681	66	9.7	227	29	12.8	861	158	18.4	3,346	453	13.5
Weakfish	Howitt	279	5	1.8	507	4	0.8	388	8	2.1	1,170	30	2.6	2,344	47	2.0
	Floy	39	0	0.0	391	1	0.3	83	0	0.0	101	0	0.0	614	1	0.2
	Combined	318	5	1.6	898	5	0.6	471	8	1.7	1,271	30	2.4	2,958	48	1.6
Red drum	Howitt	64	11	17.2	7	0	0.0	164	44	26.8	55	15	27.3	290	70	24.1
	Floy	24	0	0.0	4	0	0.0	12	0	0.0	0	0	0.0	40	0	0.0
	Combined	88	11	12.5	11	0	0.0	176	44	25.0	55	15	27.3	330	70	21.2
Southern flounder	Howitt	295	14	4.7	233	17	7.3	326	23	7.1	224	17	7.6	1,078	71	6.6
	Floy	20	1	5.0	60	3	5.0	5	0	0.0	18	0	0.0	103	4	3.9
	Combined	315	15	4.8	293	20	6.8	331	23	6.9	242	17	7.0	1,181	75	6.4
Summer flounder	Howitt	25	1	4.0	4	0	0.0	59	0	0.0	16	0	0.0	104	1	1.0
	Floy	1	0	0.0	2	0	0.0	2	0	0.0	32	0	0.0	37	0	0.0
	Combined	26	1	3.8	6	0	0.0	61	0	0.0	48	0	0.0	141	1	0.7
Black drum	Howitt	18	4	22.2	47	10	21.3	95	38	40.0	106	18	17.0	266	70	26.3
	Floy	16	2	12.5	14	1	7.1	3	0	0.0	17	0	0.0	50	3	6.0
	Combined	34	6	17.6	61	11	18.0	98	38	38.8	123	18	14.6	316	73	23.1
Sheepshead	Howitt	11	0	0.0	43	2	4.7	97	12	12.4	203	15	7.4	354	29	8.2
	Floy	22	0	0.0	39	1	2.6	0	0	0.0	0	0	0.0	61	1	1.6
	Combined	33	0	0.0	82	3	3.6	97	12	12.4	203	15	7.4	415	30	7.2
Atlantic croaker	Howitt	345	22	6.4	220	15	6.8	967	29	3.0	376	14	3.7	1,908	80	4.2
	Floy	15	0	0.0	1,028	3	0.3	477	3	0.6	26	1	3.8	1,546	7	0.5
	Combined	360	22	6.1	1,248	18	1.4	1,444	32	2.2	402	15	3.7	3,454	87	2.5
Spot	Howitt	42	1	2.4	75	0	0.0	81	2	2.5	33	1	3.0	231	4	1.7
	Floy	357	6	1.7	186	3	1.6	0	0	0.0	19	0	0.0	562	9	1.6
	Combined	499	7	1.4	261	3	1.1	81	2	2.5	52	1	1.9	793	13	1.6
Southern kingfish	Howitt	77	2	2.6	77	5	6.5	47	4	8.5	106	12	11.3	307	23	7.5
	Floy	86	0	0.0	115	1	0.9	7	1	14.3	25	0	0.0	233	2	0.9
	Combined	163	2	1.2	192	6	3.1	54	5	9.3	131	12	9.2	540	25	4.6
Gulf kingfish	Howitt	1	0	0.0	0	0	0.0	0	0	0.0	1	0	0.0	2	0	0.0
	Floy	2	0	0.0	5	0	0.0	0	0	0.0	1	0	0.0	8	0	0.0
	Combined	3	0	0.0	5	0	0.0	0	0	0.0	2	0	0.0	10	0	0.0

NOTE: Number tagged and returned does not include 112 fish tagged with both tag types.

Table 11. Number and percent of tagged fish recaptured by recreational and commercial fishermen and project personnel.

Species	Recaptures by Fishermen Type						Combined
	Recreational		Commercial		Project Personnel		
	Number	Percent	Number	Percent	Number	Percent	
Spotted seatrout	310	68.0	4	0.9	142	31.1	456
Weakfish	17	35.4	7	14.6	24	50.0	48
Red drum	71	89.9	-	-	8	10.1	79
Southern flounder	41	54.7	30	40.0	4	5.3	75
Summer flounder	-	-	1	100.0	-	-	1
Black drum	67	72.8	2	2.2	23	25.0	92
Sheepshead	23	76.7	-	-	7	23.3	30
Atlantic croaker	50	57.5	13	14.9	24	27.6	87
Spot	1	7.7	8	61.5	4	30.8	13
Southern kingfish	11	42.3	15	57.7	-	-	26
Total	591	65.2	80	8.8	236	26.0	907

Table 12. Number and average, minimum, and maximum lengths of tagged fish recaptured by recreational fishermen.

Species	Number	Total Length (mm)		
		Average	Minimum	Maximum
Spotted seatrout	213	414	268	735
Weakfish	11	326	205	392
Red drum	41	447	311	659
Southern flounder	28	340	222	436
Black drum	48	341	225	461
Sheepshead	15	300	192	393
Atlantic croaker	27	253	167	330
Southern kingfish	9	299	213	360

Table 13. Number tagged and recaptured in 50 mm length groups and percent of recaptures caught by recreational fishermen.

Length Group (mm)	NUMBER OF FISH BY SPECIES: Spotted seatrout Release Length	Spotted seatrout Recapture Length	Spotted seatrout Percent of Recaptures	Weakfish Release Length	Weakfish Recapture Length	Weakfish Percent of Recaptures	Red drum Release Length	Red drum Recapture Length	Red drum Percent of Recaptures	Southern flounder Release Length	Southern flounder Recapture Length	Southern flounder Percent of Recaptures
125	1			231						2		
175	5			1053						70		
225	45			750	2	18.2				243	1	3.6
275	123	4	1.9	209	1	9.1	25			494	7	25.0
325	986	20	9.4	364	2	18.2	135	4	9.8	209	6	21.4
375	1448	77	36.1	298	6	54.5	65	12	29.2	88	8	28.6
425	460	60	28.2	45			60	4	9.8	43	6	21.4
475	192	34	16.0	8			19	7	17.0	19		
525	81	11	5.2				3	4	9.8	7		
575	34	5	2.3				20	4	9.8	3		
625	5	2	0.9				26	5	12.2	3		
675	1						6	1	2.4			
725							6					
775							1					
975							1					
1025							1					
TOTAL	3381	213	100.0	2958	11	100.0	368	41	100.0	1181	28	100.0

Length Group (mm)	NUMBER OF FISH BY SPECIES: Black drum Release Length	Black drum Recapture Length	Black drum Percent of Recaptures	Sheepshead Release Length	Sheepshead Recapture Length	Sheepshead Percent of Recaptures	Atlantic croaker Release Length	Atlantic croaker Recapture Length	Atlantic croaker Percent of Recaptures	Southern kingfish Release Length	Southern kingfish Recapture Length	Southern kingfish Percent of Recaptures
75							33					
125	1			15			892			39		
175	37			38	1	6.7	1908	3	11.1	131		
225	165	1	2.1	134	2	13.3	406	8	29.6	122	1	11.1
275	66	8	16.7	138	6	40.0	207	13	48.2	164	3	33.3
325	62	17	35.4	53	3	20.0	8	3	11.1	76	4	44.5
375	17	18	37.5	18	3	20.0	2			8	1	11.1
425	4	3	6.2	9								
475		1	2.1	7								
525				4								
TOTAL	352	48	100.0	416	15	100.0	3456	27	100.0	540	9	100.0

NOTE: Information on the recapture length was not obtained for 201(34%) tagged fish captured by recreational fishermen.

Table 14. Number and percent of fish tagged and recaptured by sector.

Species		Creeks Number	Creeks %	Sounds Number	Sounds %	Beaches Number	Beaches %	Offshore Number	Offshore %	Combined
Spotted seatrout	Released	1409	41.7	1866	55.2	106	3.1	0	0.0	3381
	Recaptured	292	65.5	125	28.0	29	6.5	0	0.0	446
Weakfish	Released	200	6.7	2673	90.4	79	2.7	6	0.2	2958
	Recaptured	6	12.5	36	75.0	2	4.2	4	8.3	48
Red drum	Released	37	10.1	311	84.5	20	5.4	0	0.0	368
	Recaptured	9	12.7	59	83.1	3	4.2	0	0.0	71
Southern flounder	Released	232	19.6	903	76.5	45	3.8	1	0.1	1181
	Recaptured	7	10.1	31	44.9	14	20.3	17	24.7	69
Summer flounder	Released	15	10.6	95	67.4	1	0.7	30	21.3	141
	Recaptured	0	0.0	0	0.0	0	0.0	1	0.0	1
Black drum	Released	215	61.1	132	37.5	4	1.1	1	0.3	352
	Recaptured	58	63.0	24	26.1	10	10.9	0	0.0	92
Sheepshead	Released	376	90.3	36	8.7	4	1.0	0	0.0	416
	Recaptured	18	62.1	9	31.1	1	3.4	1	3.4	29
Atlantic croaker	Released	912	26.4	2216	64.1	131	3.8	197	5.7	3456
	Recaptured	41	47.7	31	36.1	7	8.1	7	8.1	86
Spot	Released	256	32.2	530	66.9	7	0.9	0	0.0	793
	Recaptured	4	36.4	2	18.2	0	0.0	5	45.4	11
Southern kingfish	Released	54	10.0	387	71.7	91	16.8	8	1.5	540
	Recaptured	1	4.5	3	13.6	8	36.4	10	45.5	22
Gulf kingfish	Released	0	0.0	4	40.0	6	60.0	0	0.0	10
	Recaptured	0	0.0	0	0.0	0	0.0	0	0.0	0

NOTE: Not all recaptures had sufficient information to ascertain exact location of capture.

tagged in the sounds may be migrants moving to the beaches for spawning or returning to the creeks. Due to weather conditions and accessibility, spotted seatrout generally receive the least amount of fishing pressure while on the beaches although they are abundant in these areas during spring and summer. They seldom occur in offshore waters and fishing pressure in these areas was virtually nonexistent. Sound and beach sectors produced 125 (28.0%) and 29 (6.5%) recoveries, respectively. Seasonally, the greatest percentage of recoveries were from the creeks during winter (41.1%) and fall (31.9%) and on the beaches during spring (34.5%) and summer (41.4%) (Table 15). Recovery rates in the sounds were over 26% from spring through fall, but dropped to 16.8% in winter.

Georgia residents fishing in state waters accounted for 284 (92%) of the 310 recreational recaptures. Of these Georgia fishermen, 245 (86%) traveled <40 km to reach their "fishing drop" or location of fish recapture while approximately 98% traveled <160 km (Table 16).

The principal bait used by recreational fishermen to catch spotted seatrout was live shrimp. Approximately 64% of all recaptures caught by recreational fishermen were on live shrimp, and an additional 5% were taken on dead shrimp (Table 17). Artificial lures accounted for 27% of the returns and were primarily used during the colder months when small shrimp (<110 mm) were less abundant and water temperatures were <16°C. Minnows, fiddlers, and cut bait accounted for the remaining 11 (3.8%) recoveries. In general, seatrout were considered by most recreational fishermen as the number one sportfish in Georgia's estuarine waters and live shrimp were the number one bait (Music and Pafford, 1982).

Approximately 49% of seatrout recoveries were caught in the immediate area of release. Of 439 recoveries with sufficient information to ascertain movement, 397 (90.4%) were recaptured within 25 km of the tagging site; 27 (6.2%) had moved 26 to 50 km; 12 (2.7%) had traveled 51-100 km; and 3 (0.7%) had moved over 100 km from the point of release (Table 18). Seatrout exhibited little tendency for long distance movements as 96.6% of the recoveries were recaptured within 50 km of the

Table 15. Number and percent of tagged fish by season and sector of recapture.

Species	Season	Area of Recapture: Creeks No.	%	Sounds No.	%	Beaches No.	%	Offshore No.	%	Combined No.	%
Spotted seatrout	Winter	120	41.1	21	16.8	1	3.4	-	-	142	31.9
	Spring	45	15.4	33	26.4	10	34.5	-	-	88	19.7
	Summer	34	11.6	34	27.2	12	41.4	-	-	80	17.9
	Fall	93	31.9	37	29.6	6	20.7	-	-	136	30.5
	Total	292	100.0	125	100.0	29	100.0	-	-	446	100.0
Weakfish	Winter	-	-	3	8.3	1	50.0	1	25.0	5	10.4
	Spring	1	16.7	4	11.1	-	-	1	25.0	6	12.5
	Summer	1	16.7	1	2.8	-	-	-	-	2	4.2
	Fall	4	66.6	28	77.8	1	50.0	2	50.0	35	72.9
	Total	6	100.0	36	100.0	2	100.0	4	100.0	48	100.0
Red drum	Winter	1	11.1	8	13.5	1	33.3	-	-	10	14.1
	Spring	-	-	5	8.5	-	-	-	-	5	7.0
	Summer	2	22.2	22	37.3	1	33.3	-	-	25	35.2
	Fall	6	66.7	24	40.7	1	33.4	-	-	31	43.7
	Total	9	100.0	59	100.0	3	100.0	-	-	71	100.0
Southern flounder	Winter	-	-	1	3.2	-	-	1	5.9	2	2.9
	Spring	1	14.3	7	22.6	1	7.1	2	11.8	11	15.9
	Summer	-	-	14	45.2	5	35.7	2	11.8	21	30.5
	Fall	6	85.7	9	29.0	8	57.2	12	70.5	35	50.7
	Total	7	100.0	31	100.0	14	100.0	17	100.0	69	100.0
Black drum	Winter	5	8.6	1	4.2	2	20.0	-	-	8	8.7
	Spring	9	15.5	4	16.7	2	20.0	-	-	15	16.3
	Summer	21	36.2	11	45.8	4	40.0	-	-	36	39.1
	Fall	23	39.7	8	33.3	2	20.0	-	-	33	35.9
	Total	58	100.0	24	100.0	10	100.0	-	-	92	100.0
Sheepshead	Winter	-	-	-	-	-	-	-	-	-	-
	Spring	7	38.9	4	44.5	-	-	-	-	11	37.8
	Summer	6	33.3	2	22.2	-	-	1	100.0	9	31.1
	Fall	5	27.8	3	33.3	1	100.0	-	-	9	31.1
	Total	18	100.0	9	100.0	1	100.0	1	100.0	29	100.0
Atlantic croaker	Winter	2	4.9	1	3.2	-	-	-	-	3	3.5
	Spring	24	58.5	3	9.7	-	-	1	14.3	28	32.5
	Summer	13	31.7	18	58.1	3	42.8	2	28.6	36	41.9
	Fall	2	4.9	9	29.0	4	57.2	4	57.1	19	22.1
	Total	41	100.0	31	100.0	7	100.0	7	100.0	86	100.0
Spot	Winter	1	25.0	-	-	-	-	-	-	1	9.1
	Spring	1	25.0	1	50.0	-	-	5	100.0	7	63.6
	Summer	2	50.0	-	-	-	-	-	-	2	18.2
	Fall	-	-	1	50.0	-	-	-	-	1	9.1
	Total	4	100.0	2	100.0	-	-	5	100.0	11	100.0
Southern kingfish	Winter	1	100.0	-	-	2	25.0	-	-	3	13.6
	Spring	-	-	-	-	4	50.0	8	80.0	12	54.6
	Summer	-	-	2	66.7	2	25.0	2	20.0	6	27.3
	Fall	-	-	1	33.3	-	-	-	-	1	4.5
	Total	1	100.0	3	100.0	8	100.0	10	100.0	22	100.0

NOTE: Of the 919 recaptures, only 874 fish included sufficient information to ascertain date and location of capture.

Table 16. Distance Georgia recreational fishermen traveled to reach the fishing area where tagged fish were recaptured.

Species		Distance Traveled By Georgia Recreational Fishermen								
	Kilometers:	1-40	41-80	81-120	121-160	161-240	241-320	321-400	401-480	Over 480
	Miles:	1-25	26-50	51--75	76-100	101-150	151-200	201-250	251-300	Over 300
Spotted seatrout		245	14	10	9	-	1	2	1	2
Weakfish		13	1	1	-	1	-	-	1	-
Red drum		53	2	3	3	6	-	-	-	-
Southern flounder		22	2	-	-	1	-	2	-	-
Black drum		49	4	-	1	1	-	-	-	-
Sheepshead		18	1	1	-	-	-	-	1	-
Atlantic croaker		32	4	2	-	-	-	-	2	2
Spot		1	-	-	-	-	-	-	-	-
Southern kingfish		7	1	2	-	-	-	-	-	-
Total		440	29	19	13	9	1	4	5	4
Percent		84.0	5.5	3.6	2.5	1.7	0.2	0.8	0.9	0.8

Table 17. Number and percent of recreational recaptures by bait type used to catch tagged Georgia fish.

	Number and Percent of Recaptures by Bait Type																
	Shrimp				Artificial Lure		Cut Bait		Fiddler		Minnow		Mussel		Sand Flea		
	Live		Dead														
Sportfish	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	Total
Spotted seatrout	186	(64.4)	14	(4.8)	78	(27.0)	1	(0.3)	2	(0.7)	8	(2.8)					289
Weakfish	6	(42.9)	6	(42.9)	1	(7.1)	1	(7.1)									14
Red drum	62	(87.2)	7	(9.8)	1	(1.4)	1	(1.4)									71
Southern flounder	18	(72.0)	2	(8.0)	1	(4.0)					4	(16.0)					25
Black Drum	29	(36.6)	40	(50.6)					7	(8.9)	1	(1.3)	1	(1.3)	1	(1.3)	79
Sheepshead	4	(17.4)	2	(8.7)					17	(73.9)							23
Atlantic croaker	7	(16.3)	36	(83.7)													43
Southern kingfish			5	(100.0)													5
Combined	316	(56.9)	114	(20.5)	81	(14.6)	3	(0.6)	26	(4.7)	13	(2.3)	1	(0.2)	1	(0.2)	555

NOTE: Recreational recaptures caught with hook and line gear.
All recaptures did not include bait type information.
Project personnel accounted for 12 hook and line black drum recaptures.

Table 18. Days at large and distance traveled for spotted seatrout, *Cynoscion nebulosus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Days At	Distance Traveled (km)								
Large	0	0.1-1	1-5	6-25	26-50	51-100	101-200	Total	Percent
1 - 50	37	1	9	29	8	-	-	84	19.1
51 - 100	54	2	5	15	5	1	-	82	18.7
101 - 150	17	3	4	16	3	4	1	48	11.0
151 - 200	11	4	3	22	3	-	1	44	10.0
201 - 300	30	4	9	25	5	5	1	79	18.0
301 - 500	45	2	4	12	3	2	-	68	15.5
501 - 750	11	-	-	8	-	-	-	19	4.3
750 - 1,000	4	-	-	2	-	-	-	6	1.4
Over 1,000	7	-	1	1	-	-	-	9	2.0
Total	216	16	35	130	27	12	3	439	100.0
Percent	49.2	3.6	8.0	29.6	6.2	2.7	0.7	100.0	

NOTE: Only 439 of the 456 recaptures had sufficient information to calculate distance traveled.

release site. However, 15 (3.4%) returns had traveled more than 50 km before recapture. These recaptures indicated northward movement generally during spring and summer, and southward movement during the fall (Table 19). Only three (0.6%) spotted seatrout were captured beyond Georgia waters. For the most part, movement was limited as compared to other inshore species such as black drum and southern flounder. Movement was primarily seasonal and was generally confined to a particular estuarine system. Basically, most adult seatrout move out of the upper estuaries onto the beaches and shoal areas primarily during spring and early summer during the spawning season and return to the upper estuaries during late summer and fall (Table 20). The high return rate (49.2%) for seatrout recaptured in the immediate area of tagging indicates movement may often be within a territorial creek-river-sound-beach system. Between 64 and 75 percent of the seatrout at large from 500 to over 1,000 days were caught in the immediate area of release, indicating territorial behavior of older fish.

Even though movement was significantly greater toward the beaches during the warm months and toward the creeks in the cooler months, yearly emigration and immigration of seatrout was approximately equal (Table 20). The greatest seasonal movement occurred during summer as indicated by a mean recovery distance of 16.2 km (Table 21). This increase in movement during summer coincided with the spawning season when most seatrout moved into areas of higher salinities.

Overall, there appeared to be little relation between distance traveled and size of fish. However, recovery data indicated more movement or dispersal of young individuals with less movement for seatrout larger than 450 mm (Tables 7 and 18). Recovery data also indicated that time at large had little effect on distance traveled as 14 recoveries at large more than two years exhibited a mean movement of only 3.6 km as compared to the overall mean movement of 8.9 km.

Recovery information on distance traveled by Georgia seatrout was similar to studies conducted on the east coast of Florida and in the Gulf of Mexico. Comparison of return rates and distances traveled by tagged fish for several populations of spotted seatrout are shown in Tables 22 and 23.

Table 19. List of spotted seatrout recaptured greater than 50 km from the place of tagging.

Direction of Movement	Distance Traveled (km)	Season of Capture	Days at Large	Release Length (mm)	Location of Capture
Northward	55	Spring	54	383	Patterson Island
	59	Summer	199	287	McQueen's Inlet
	63	Summer	177	390	St. Catherine Beach
	77	Summer	471	391	Wahoo River
	78	Spring	160	377	Sapelo Sound
	78	Spring	160	374	Sapelo Sound
	81	Fall	217	389	St. Catherine Sound
	82	Winter	272	397	Harris Neck River
	101	Summer	153	377	Shellman Bluff
	105	Spring	119	378	Hell's Gate
	110	Summer	219	373	Wassaw Sound
Southward	51	Fall	272	359	Fernandina, Florida
	76	Fall	280	324	St. Mary's River
	85	Fall	393	360	Fort George Inlet, Florida
	102	Fall	204	329	Jacksonville, Florida

Table 20. Seasonal movement of spotted seatrout, *Cynoscion nebulosus*, tagged in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Season	Length Group (mm)	Caught In Area Of Release	Direction Moved By Recaptured Tagged Fish: Movement Within Estuary: Creek to Beach	Beach To Creek	Movement Out Of Estuary: North	South
Winter	201-250	1	-	-	-	-
	251-300	7	-	1	-	-
	301-350	25	-	5	2	6
	351-400	45	5	8	3	3
	401-450	18	-	2	-	5
	451-500	5	-	1	-	-
	501-550	-	-	-	-	-
	551-600	-	-	-	-	-
	Total	101	5	17	5	14
	Percent	71.1	3.5	12.0	3.5	9.9
Spring	201-250	1	-	-	-	-
	251-300	3	-	-	-	-
	301-350	8	4	1	3	1
	351-400	13	11	3	7	11
	401-450	2	1	-	-	-
	451-500	2	3	2	1	4
	501-550	4	2	-	-	1
	551-600	-	-	-	-	-
	Total	33	21	6	11	17
	Percent	37.5	23.9	6.8	12.5	19.3
Summer	201-250	-	-	-	-	-
	251-300	1	-	-	2	-
	301-350	8	3	1	2	5
	351-400	12	12	3	4	11
	401-450	4	1	-	1	5
	451-500	-	-	-	-	-
	501-550	2	-	-	-	-
	551-600	-	-	-	-	1
	Total	27	16	4	9	24
	Percent	33.7	20.0	5.0	11.3	30.0
Fall	201-250	-	-	-	1	-
	251-300	1	-	-	-	1
	301-350	22	7	5	6	11
	351-400	23	5	7	5	16
	401-450	4	1	4	1	3
	451-500	1	-	1	-	-
	501-550	2	-	-	-	-
	551-600	2	-	-	-	-
	Total	55	13	17	13	31
	Percent	42.6	10.1	13.2	10.1	24.0
Combined	Total	216	55	44	38	86
	Percent	49.2	12.5	10.0	8.7	19.6

Table 21. Number of recaptures and average and maximum distance traveled by season of capture.

	Season											
	Winter			Spring			Summer			Fall		
		Distance (km)			Distance (km)			Distance (km)			Distance (km)	
Species	No.	Avg.	Max.	No.	Avg.	Max.	No.	Avg.	Max.	No.	Avg.	Max
Spotted seatrout	127	5.0	82	102	6.5	105	79	16.2	110	131	9.9	102
Weakfish	6	27.8	167	6	16.7	80	1	0.0	0.0	33	3.5	39
Red drum	11	30.8	178	7	8.3	49	23	2.4	18	38	16.8	161
Southern flounder	3	38.4	89	12	202.2	556	19	21.0	159	35	26.7	250
Summer flounder	0	-	-	1	18.5	19	0	-	-	0	-	-
Black drum	6	159.1	619	16	14.2	213	36	23.4	217	34	44.5	463
Sheepshead	3	1.5	4.4	7	17.9	98	12	5.0	30	8	6.7	24
Atlantic croaker	1	0.0	0.0	25	15.8	179	36	9.1	113	23	8.2	37
Spot	1	2.0	2.0	8	23.1	47	2	0.0	0.0	2	58.8	118
Southern kingfish	2	304.8	537	8	18.0	41	9	21.9	128	1	0.0	0.0

Table 22. Comparison of tag recovery rates for several major fish movement investigations.

Species	Investigation								
	Present study Georgia			Beaumariage (1969)[1/] Florida			Matlock and Weaver (1979) Texas		
	Number Released	Number Returned	Number Returned	Number Released	Number Returned	Number Returned	Number Released	Number Returned	Number Returned
Spotted seatrout *Cynoscion nebulosus*	3,381	456	13.5	3,957	537	13.6	303	7	2.3
Weakfish *Cynoscion regalis*	2,958	48	1.6	9	3	33.3	-	-	-
Red drum *Sciaenops ocellatus*	368	79	21.5	690	328	47.5	1,341	159	11.6
Southern flounder *Paralichthys lethostigma*	1,181	75	6.4	-	-	-	199	9	4.5
Summer flounder *Paralichthys dentatus*	141	1	0.7	4	0	0.0	-	-	-
Black drum *Pogonias cromis*	352	92	26.1	538	199	37.0	1,572	53	3.4
Sheepshead *Archosargus probatocephalus*	416	30	7.2	2,640	917	34.7	205	6	2.9
Atlantic croaker *Micropogonias undulatus*	3,456	87	2.5	-	-	-	25	1	4.0
Spot *Leiostomus xanthurus*	793	13	1.6	-	-	-	4	0	0.0
Southern kingfish *Menticirrhus americanus*	540	26	4.8	7	1	14.3	-	-	-
Gulf kingfish *Menticirrhus littoralis*	10	0	0.0	133	28	21.1	1	0	0.0

1/ Includes movement information on spotted seatrout tagged during the 1961-65 Schlitz and the 1963 state sponsored programs (Ingle et al.,1962; Topp, 1963; Beaumariage, 1964; Beaumariage and Wittich, 1966).

NOTE: A dash (-) denotes species not tagged.

Table 23. Comparison of distance in kilometers and nautical miles traveled by fish for several populations of spotted seatrout, *Cynoscion nebulosus*.

Investigator	Area	Number Released	Number Returned	Percent Returned	Percent of Fish Movement: Kilometer / Mile	0-56 / 0-30	57-111 / 31-30	112-167 / 61-90	168-222 / 91-120	>222 / >120	Maximum Distance Traveled: Kilometer	Mile
Present Study	Georgia	3,381	456	13.5		96.7	3.3	-	-	-	110	59
Moffett (1961)	West Florida	5,345	577	10.8		95.3	1.3	2.5	0.4	0.4	584	315
Beaumariage (1969)[1/]	Florida	3,957	537	13.6		99.6	0.4	-	-	-	83	45
Overstreet (1983)	Mississippi	133	14	10.5		100.0	-	-	-	-	26	14
Matlock and Weaver (1979)	Texas	303	7	2.3		100.0	-	-	-	-	43	23
Adkins et al. (1979)	Louisiana	2,604	30	1.1		100.0[2/]	-	-	-	-	>4	>2

[1/] Includes movement information on spotted seatrout tagged during the 1961-65 Schlitz and the 1963 state sponsored programs.

[2/] One seatrout was reported to have traveled more than 3.7 km, but actual distance traveled was not included.

NOTE: A dash (-) denotes no recaptures.

Length-Weight Relationship

Length and weight measurements were taken for 1,369 spotted seatrout ranging from 15 to 750 mm and 0.1 to 4,575 g. The length-weight relationship equation for a random sample of 710 seatrout was log W = 2.949 logL - 4.848. The correlation coefficient (r^2 value) for length-weight for seatrout was 0.9535 ($P < 0.0001$). Least-squares regression analyses on the length-weight relationships for male, female, and all spotted seatrout combined appear in Table 24. Figure 15 illustrates the length-weight relationships for spotted seatrout.

Length-weight relationships calculated for Georgia seatrout showed isometric growth (b = 2.949). The greatest lengths recorded during this study for males and females were 598 and 750 mm, respectively. The heaviest male weighed 2,197 g and the heaviest female was 4,575 g. There were no significant differences between the average weights of similar size male and female seatrout for lengths less than 300 mm, but in specimens over 300 mm, females were heavier than males. Georgia seatrout were heavier at given lengths than fish from the Gulf of Mexico. However, Chesapeake Bay seatrout were heavier than similar sized specimens from Georgia or the Gulf (Table 25).

Age and Growth

An essential component of any investigation of a population is to determine the age of fish for the estimation of growth rate, longevity, and age at maturity or spawning. Sampling fish populations can pose several difficulties for age analyses, and seldom is there a technique that will randomly sample all size groups to obtain the age composition of an entire population. Habitat and feeding preference, behavior patterns, and movements may vary with age, size and season. Also, most types of sampling gear are size selective, and gear efficiency may vary with environmental conditions.

Age and growth studies based on the scale technique have been validated as an ageing method for spotted seatrout (Welsh and Breder, 1924; Pearson, 1929; Klima and Tabb, 1959; Moffett, 1961; Tabb, 1961;

Table 24. Length-weight equations for marine sportfish collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

	Sexes Combined			Females			Males		
Species	Length-Weight Equation	N	r^2 Value	Length-Weight Equation	N	r^2 Value	Length-Weight Equation	N	r^2 Value
Spotted seatrout	logW=2.949 logL-4.848	710 1/	.95	logW=2.824 logL-4.516	408	.93	logW=2.683 logL-4.182	277	.86
Weakfish	logW=2.920 logL-4.774	327	.95	logW=2.972 logL-4.905	258	.92	logW=2.863 logL-4.636	43	.94
Red drum	logW=2.722 logL-4.220	103	.98	logW=2.715 logL-4.138	20	.91	logW=2.799 logL-4.431	27	.99
Southern flounder	logW=3.091 logL-5.157	233	.98	logW=2.970 logL-4.844	105	.98	logW=2.984 logL-4.893	12	.95
Summer flounder	logW=2.920 logL-4.807	25	.99						
Black drum	logW=3.075 logL-4.969	79	.99	logW=3.177 logL-5.235	18	.99	logW=2.921 logL-4.609	28	.98
Sheepshead	logW=2.885 logL-4.412	118	.97	logW=2.899 logL-4.453	59	.94	logW=2.723 logL-3.977	39	.96
Atlantic croaker	logW=3.195 logL-5.367	260	.96	logW=3.143 logL-5.235	124	.97	logW=3.159 logL-5.279	39	.97
Spot	logW=3.121 logL-5.096	325	.89	logW=3.042 logL-4.901	167	.91	logW=3.007 logL-4.835	126	.87
Southern kingfish	logW=3.160 logL-5.360	195	.99	logW=3.334 logL-5.780	119	.99	logW=3.221 logL-5.523	14	.97
Gulf kingfish	logW=2.872 logL-4.675	28	.81	logW=2.913 logL-4.776	26	.80			

1/ Number in sample for sexes combined includes juveniles, males and females.

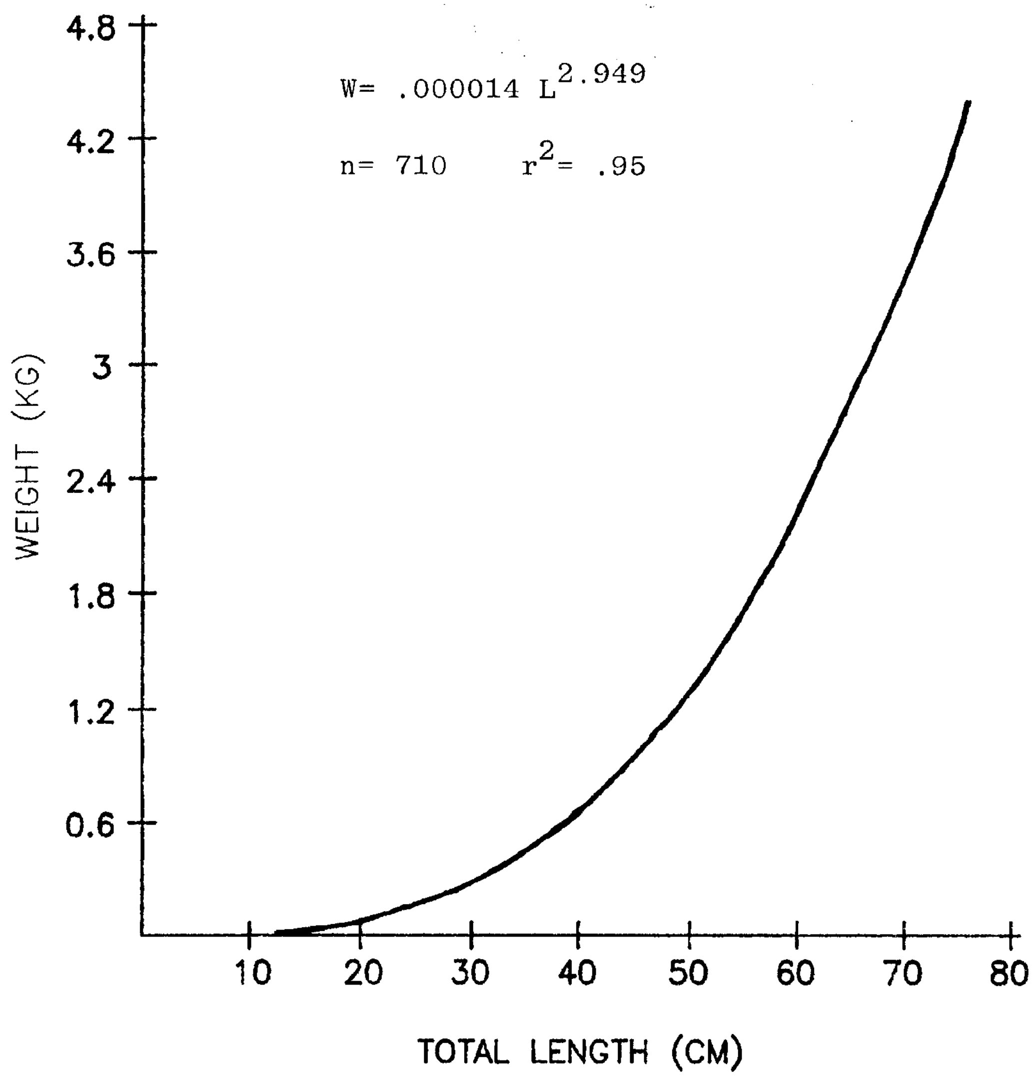


Figure 15. Length-weight relationship of spotted seatrout, *Cynoscion nebulosus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Table 25. Comparison of length-weight relationships of several populations of spotted seatrout, *Cynoscion nebulosus*.

Study	Location	Sex	Length - Weight Equation	Weight of Fish (g)		
				350 mm	500 mm	700 mm
Present Study	Georgia	Male	logW=2.683 logL-4.182	441	1,147	2,829
		Female	logW=2.824 logL-4.516	466	1,277	3,303
		Sexes Combined[1/]	logW=2.949 logL-4.848	452	1,293	3,487
Pearson (1928)	Texas	Sexes Combined	-	-	1,248*	3,632*
Moffett (1961)	Florida	Sexes Combined	logW=3.113 logL-5.333	416	1,261	3,596
Hein et al. (1980)	Louisiana	Sexes Combined	logW=3.154 logL-5.422	391	1,204	3,480
Brown (1981)	Virginia	Male	logW=3.244 logL-5.598	448	1,424	4,240
		Female	logW=2.986 logL-4.924	470	1,364	3,724
		Sexes Combined	logW=3.043 logL-5.072	469	1,388	3,864

1/ Sexes combined for Georgia includes juveniles, males and females.

NOTE: A dash (-) denotes information not provided by investigator.
An asterisk (*) denotes the weight was converted from pounds.

Hein et al., 1980; Brown, 1981). Scale annuli marks were described by Klima and Tabb (1959) and Tabb (1961) as not forming by the typical crowding of the circuli as is the case with many fish scales, but are formed by definite breaks and disconformities in the circuli pattern. These breaks in circuli are generally detectable by the addition of new radii in the anterior region and the cutting over of recent circuli over older circuli in the lateral regions of the scale. Although not as widely used, otoliths have been validated as an ageing technique on fishes from temperate waters (Lux, 1971; Bagenal, 1973; Theiling, 1974; Barger and Johnson, 1980).

Scale samples from 740 seatrout ranging from 56 to 750 mm were examined. Of these, 579 (78%) were considered legible for age determinations. Otolith sections from these 579 fish were also examined to document and compare the annuli counts ascertained from scale analyses. Annulus formation on scales and otoliths was found to be relatively simultaneous with the otolith rings being detectable slightly earlier than scale annuli for fish older than one year. The first annulus on scales was often incomplete and difficult to distinguish. Bagenal (1978) stated that in temperate latitudes annuli marks may fail to appear in age 0 fish that overwinter at small sizes. The formation of the first otolith ring was often obscured within the core structure and was seldom detectable in otoliths from Georgia seatrout. Considering this scale-otolith year mark difference, scales and otoliths examined from the same fish exhibited a 98.9% agreement in annuli counts.

Calculations of mean monthly growth of marginal increments validated that scale annuli were formed only once annually. A single annulus formation was detectable on seatrout scales during late February and March with all scales bearing recent annuli by mid-April.

The use of scales and their marks in age and growth studies depends upon the relationship between growth of the fish and its scale. Least squares regression analyses on the relationship between fish length and scale radius were performed. The correlation coefficient (r^2 value) of 0.77 ($P < 0.0001$) suggests the relationship was sufficiently linear to warrant direct proportion calculations to determine fish length at time of annulus formation. Empirical and mean back-calculated total lengths by age for seatrout are shown in Table 26. Figure 16 illustrates the length-age relationship for seatrout, and the principle of least squares was employed to draw the line of best fit. Equations for the length-age relationships for male, female, and all seatrout combined are shown in Table 27. Table 28 shows the empirical and weighted mean back-calculated lengths for juvenile, male, female and all spotted seatrout combined.

To document the annual growth rate determined from back-calculations, mean growth rates for tagged seatrout at large for approximately one, two, and three year intervals were calculated. The average release length and approximate age for 31 seatrout at large from 11 to 13 months was 358 mm and age III, respectively. The mean annual growth for seatrout of that approximate age may range from 56 to 79 mm (Table 28). The estimated mean annual growth for the 31 recaptured seatrout was 68 mm, substantiating the estimated annual growth for that size fish based on back-calculation data. Also, seatrout approximately three years old when tagged and at large for two and three year intervals exhibited mean growth rates of 137 and 161 mm, respectively. These observed growth increases are fairly consistent with values derived by combining the annual growth estimates for the 3rd and 4th year's growth increase (135 mm) and the 3rd, 4th, and 5th year's growth (181 mm). One female seatrout measuring 378 mm when released and at large for 1,442 days exhibited a growth of 294 mm. However, this growth increase was slightly greater than the back-calculated estimated growth for that size female at large four years.

The oldest seatrout collected in Georgia were age VIII for females and age VI for males. These findings are similar to those for fish studied in Texas and Florida (Table 29). However, ageing studies indicate that trout in Virginia live substantially longer than those in more southerly waters. Maximum age of seatrout from the Chesapeake Bay area was determined to be XV (Brown, 1981).

A substantial overlap in sizes of seatrout in Georgia occurred between ages II and VI. Brown (1981) observed similar findings for

Table 26. Mean back-calculated total lengths for spotted seatrout, *Cynoscion nebulosus*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back Calculated lengths of Successive Scale Rings							
				1	2	3	4	5	6	7	8
0	31	56 - 258	152								
1	10	245 - 373	302	226							
2	202	216 - 435	319	173	270						
3	202	264 - 615	381	186	293	358					
4	64	320 - 609	467	195	311	388	444				
5	34	430 - 631	524	193	310	384	449	493			
6	29	430 - 608	526	180	285	350	408	463	504		
7	5	535 - 658	612	183	296	372	433	505	563	598	
8	2	585 - 750	668	195	301	355	430	519	581	638	665
		Weighted Means		184	287	366	436	482	516	609	665
		Growth Increments		184	103	79	56	46	34	93	56

NOTE: Lengths measured in millimeters.

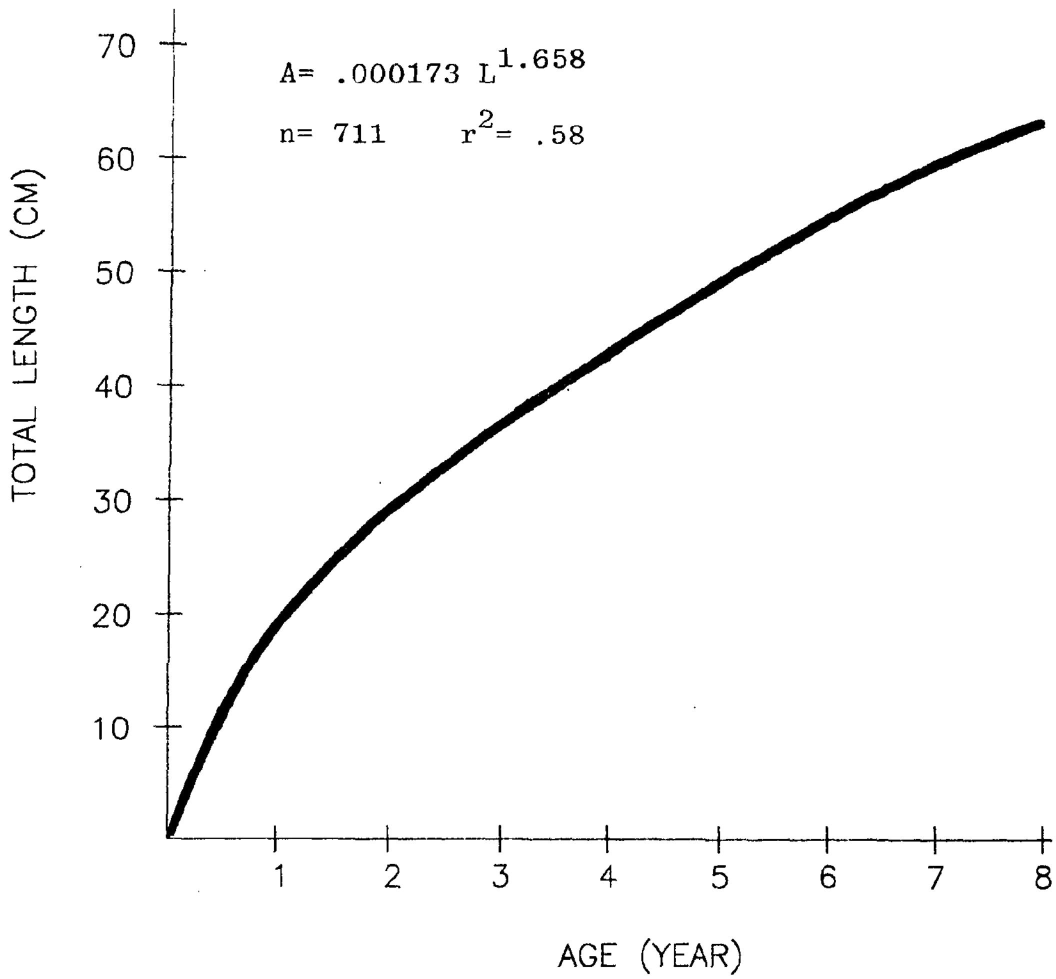


Figure 16. Length-age relationship of spotted seatrout, *Cynoscion nebulosus*, collected in Glynn County, Georgia.

Table 27. Length-age equations for marine sportfish collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Species	Sexes combined Length-Age Equation	$N^{1/}$	r^2 Value	Females Length-Age Equation	N	r^2 Value	Males Length-Age Equation	N	r^2 Value
Spotted seatrout	logA=1.658 logL-3.761	711	.58	logA=1.700 logL-3.894	407	.63	logA=1.880 logL-4.237	277	.46
Weakfish	logA=1.625 logL-3.606	328	.67	logA=1.657 logL-3.692	259	.60	logA=1.618 logL-3.543	43	.86
Red drum 2/	logA=1.691 logL-4.415	104	.52	logA=1.546 logL-4.044	20	.44	logA=1.952 logL-5.159	27	.76
Southern flounder	logA=1.191 logL-2.646	233	.63	logA=1.277 logL-2.887	105	.72	logA=1.029 logL-2.140	12	.69
Black drum 2/	logA=1.771 logL-4.158	81	.87	logA=1.754 logL-4.111	18	.95	logA=1.419 logL-3.242	30	.56
Sheepshead	logA=1.953 logL-4.366	118	.86	logA=1.905 logL-4.244	59	.89	logA=1.854 logL-4.102	39	.81
Atlantic croaker	logA=1.953 logL-4.326	260	.14	logA=1.963 logL-4.354	124	.20	logA=2.071 logL-4.570	39	.01
Spot	logA=1.877 logL-3.965	326	.31	logA=1.695 logL-3.539	167	.29	logA=2.080 logL-4.432	127	.25
Southern kingfish	logA=1.533 logL-3.366	196	.47	logA=1.586 logL-3.511	120	.56	logA=1.737 logL-3.783	14	.84
Gulf kingfish	logA=0.889 logL-1.811	28	.51	logA=0.889 logL-1.855	26	.52			

1/ Number in sample for sexes combined includes juveniles, males, and females.

2/ Equation based on individuals less than four years of age.

NOTE: Number of summer flounder not sufficient to warrant length-age equation.

Table 28. Number, empirical and back-calculated total lengths, and growth increments by sex and age for spotted seatrout, *Cynoscion nebulosus*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Sex	Age 1	2	3	4	5	6	7	8
Juveniles								
Number	0	1						
Mean Length at Capture	-	232						
Back-Calculated Length	121	196						
Growth Increment	121	75						
Males								
Number	3	102	83	13	4	9		
Mean Length at Capture	275	306	342	390	493	470		
Back-Calculated Length	175	268	328	378	424	449		
Growth Increment	175	93	60	50	46	25		
Females								
Number	7	99	119	51	30	20	5	2
Mean Length at Capture	314	332	408	487	528	552	612	667
Back-Calculated Length	190	300	384	451	496	539	609	665
Growth Increment	190	110	84	67	45	43	70	56
Combined								
Number	10	202	202	64	34	29	5	2
Mean Length at Capture	302	319	381	467	524	526	612	668
Back-Calculated Length	184	287	366	436	482	516	609	665
Growth Increment	184	103	79	56	46	34	93	56

NOTE: Lengths measured in millimeters.

Table 29. Comparison of mean back-calculated total lengths at age for several populations of spotted seatrout, *Cynoscion nebulosus*.

Study	Location	Sex	Back-Calculated Length at Age											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Present Study	Georgia	Male	175 1/	268	328	378	424	449						
		Female	190	300	384	451	496	539	609	665				
		Combined	184	267	366	436	482	516	609	665				
Welsh and Breder* (1924)	West Florida	Combined	140	281	378	439	488	525						
Pearson (1929)*	Texas	Combined	183	293	366	427	488	537	598	634				
Klima and Tabb* (1959)	Northwest Florida	Male	140	229	305	371	416	450						
		Female	143	233	315	384	454	516	533					
		Combined	142	232	311	381	450	515	533					
	Fort Myers Florida	Male	156	251	316	378	432	533						
		Female	160	255	325	393	453	499	526	534				
		Combined	159	254	322	390	449	525						
Moffett (1961)*														
	Cedar Key Florida	Male	157	251	321	394	464	529						
		Female	159	259	328	394	467							
		Combined	159	257	327	394	466							
Tabb (1961)*	East Florida	Combined	201	303	387	468	558	650	684	761				
Brown (1981)	Virginia	Male	153	244	313	378	432	440	501	554				
		Female	191	279	347	404	449	493	523	560	588	644		
		Combined	170	260	353	414	441	475	521	561	603	648	687	721

* Converted from standard lengths to total lengths using the formula TL= 1.22 SL

1/ Lengths measured in millimeters.

trout in the Chesapeake Bay area. However, the magnitude of overlap in length-age shown in Table 26 can be partially explained when the lengths are examined by sex (Tables 30 and 31). In general, female seatrout in Georgia were significantly larger than males of equal age. Similar size-age differences between sexes were also documented for seatrout in Florida and Virginia (Klima and Tabb, 1959; Brown, 1981).

Growth rates of Georgia seatrout were not significantly different from those reported from other areas (Table 29). Growth in Georgia was rapid during the first three years of life with daily growth increments of 0.50, 0.28, and 0.22 mm, respectively (Table 32). Daily growth rates slowed after age III or IV. Also, annual growth increments varied widely in older fish, but this may be attributed to sexual growth differences and the low number of large fish collected (Table 28).

To show how such variations of growth rates may occur within a population or between different populations, ages of seatrout collected in Glynn County during 1979 were compared to fish collected during 1982 (Tables 33 and 34). Weighted mean back-calculated lengths ranged from 2 to 43 mm larger for the 1982 seatrout with an average yearly increase of 24 mm over the 1979 fish for the first five years of life. This variation in length-age of Georgia seatrout may be the result of two severe winters during 1977 and 1978. These severe winters designated by the Federal Government as "shrimp disasters" not only killed crustaceans but also killed fish and other estuarine dependent organisms as well (Music, 1979). Such natural estuarine disasters could temporarily eliminate or significantly limit many food species of the spotted seatrout. It is assumed the general lack of abundant food for good nutrition as well as the increased energy spent seeking scarce prey would result in less fish growth.

Maturity and Spawning

Georgia's spotted seatrout are year-round residents in coastal waters and for the most part are estuarine specific to a particular sound system. They are spawned in and utilize their particular estuarine

Table 30. Mean back-calculated total lengths for male spotted seatrout, *Cynoscion nebulosus*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Ring Class	Number	Length Range at Capture	Mean Length at Capture	Mean Back Calculated Lengths of Successive Scale Rings					
				1	2	3	4	5	6
0	4	159 - 204	183						
1	3	245 - 301	275	229					
2	101	216 - 377	306	167	261				
3	83	285 - 403	83	181	273	326			
4	13	320 - 454	390	179	285	340	379		
5	4	430 - 598	493	162	267	341	392	447	
6	9	430 - 532	470	170	269	322	367	411	449
		Weighted Means		175	268	328	378	424	449
		Growth Increments		175	93	60	50	46	25

NOTE: Lengths measured in millimeters.

Table 31. Mean back-calculated total lengths for female spotted seatrout, *Cynoscion nebulosus*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back Calculated Lengths of Successive Scale Rings							
				1	2	3	4	5	6	7	8
0	3	157 - 258	204								
1	7	265 - 373	314	225							
2	99	223 - 435	332	181	281						
3	119	264 - 615	408	190	307	380					
4	51	379 - 609	487	199	317	401	460				
5	30	465 - 631	528	198	315	390	457	499			
6	20	494 - 608	552	185	292	362	426	486	528		
7	5	535 - 658	612	183	296	372	433	505	563	598	
8	2	585 - 750	668	195	301	355	430	519	581	638	665
		Weighted Means		190	300	384	451	496	539	609	665
		Growth Increments		190	110	84	67	45	43	70	56

NOTE: Lengths measured in millimeters.

Table 32. Estimated mean daily growth of marine sportfish by sex for each year of life.

Species	Sex	Mean Daily Growth for Year of Life (mm) 1	2	3	4	5	6
Spotted seatrout	Male	0.48	0.25	0.16	0.14	0.13	0.07
	Female	0.52	0.30	0.23	0.18	0.12	0.12
	Combined	0.50	0.28	0.22	0.15	0.13	0.09
Weakfish	Male	0.41	0.27	0.16	0.11	-	-
	Female	0.46	0.27	0.18	0.15	0.16	0.15
	Combined	0.44	0.28	0.18	0.14	0.18	0.15
Red drum	Male	1.19	0.61	0.25	-	-	-
	Female	1.13	0.64	-	-	-	-
	Combined	1.10	0.69	0.26	-	-	-
Southern flounder	Male	0.33	0.34	0.27	-	-	-
	Female	0.47	0.44	0.35	0.34	0.06	0.21
	Combined	0.43	0.44	0.34	0.34	0.06	0.21
Summer flounder	Combined	0.39	-	-	-	-	-
Black drum	Male	0.52	0.40	0.25	0.18	-	-
	Female	0.53	0.41	0.32	0.25	0.21	0.10
	Combined	0.54	0.38	0.29	0.27	0.24	0.10
Sheepshead	Male	0.40	0.29	0.24	0.13	0.10	0.09
	Female	0.40	0.30	0.21	0.17	0.14	0.09
	Combined	0.41	0.28	0.22	0.15	0.13	0.09
Atlantic croaker	Male	0.44	0.18	-	-	-	-
	Female	0.45	0.20	0.15	0.15	0.04	-
	Combined	0.45	0.19	0.16	0.15	0.04	-
Spot	Male	0.37	0.19	0.03	-	-	-
	Female	0.33	0.21	0.06	-	-	-
	Combined	0.35	0.20	0.05	-	-	-
Southern kingfish	Male	0.41	0.23	0.11	-	-	-
	Female	0.43	0.34	0.13	0.09	-	-
	Combined	0.42	0.34	0.12	0.11	-	-
Gulf kingfish	Male	0.27	-	-	-	-	-
	Female	0.33	0.40	-	-	-	-
	Combined	0.33	0.40	-	-	-	-

NOTE: Dash (-) denotes fish were not collected in age group.

Sex combined includes juveniles, males, and females.

Table 33. Mean back-calculated total lengths for spotted seatrout, *Cynoscion nebulosus*, through age V for fish collected in the coastal waters of Glynn County, Georgia during 1979.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back Calculated Lengths of Successive Scale Rings				
				1	2	3	4	5
0	2	138 - 148	143					
1	2	293 - 323	308	225				
2	120	223 - 422	335	183	281			
3	138	264 - 521	372	190	294	357		
4	21	339 - 544	423	176	296	363	412	
5	10	440 - 518	488	196	310	383	434	475
		Weighted Means		186	289	359	419	475
		Growth Increments		186	103	70	60	56

NOTE: Lengths measured in millimeters.

Table 34. Mean back-calculated total lengths for spotted seatrout, *Cynoscion nebulosus*, **through age V** for fish collected in the coastal waters of Glynn County, Georgia during 1982.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back-Calculated Lengths of Successive Scale Rings 1	2	3	4	5
0	27	56 - 258	155					
1	8	245 - 373	301	227				
2	39	252 - 435	316	169	271			
3	43	272 - 615	412	182	296	370		
4	26	320 - 609	491	206	321	400	458	
5	14	430 - 631	554	201	314	396	466	518
		Weighted Means		188	295	384	461	518
		Growth Increments		188	107	89	77	57

NOTE: Lengths measured in millimeters.

systems as nursery grounds for all stages of development and growth. A description of the classification of maturity stages of gonadal development in fishes is presented in Table 6.

During this study, the smallest spotted seatrout for which the sex was determined through gross examination was 157 mm for females and 159 mm for males. The smallest female to exhibit maturing or prespawning ovaries (stage III or greater) was a 229 mm (age II) specimen in its third year of life. The smallest male stage III or greater was 342 mm, but collection of the smaller reproductive males may have been biased by gear selectivity as males are reported to mature earlier than females (Guest and Gunter, 1958).

Seatrout are generally believed to mature at one to three years of age. Pearson (1929) found that Texas seatrout matured at the end of their second year but did not spawn until the third. Miles (1950) reported that 10% reached maturity at the end of their first year (16 cm length), 50% at the end of the second year (25 cm length) and that sexual maturity was obtained by the end of the third year. Moody (1950) found that females did not spawn until they reached 240 to 250 mm length in Cedar Key, Florida.

Table 35 presents the stages of gonadal development for female and male spotted seatrout by month. Females exhibiting maturity stages I through III were collected every month, but spawning activity began in April when 10.2% of the females exhibited advanced ovarian development (stages IV through VII or spent). Spawning activity peaked in May when 43.4% of the females showed advanced development, but in June there was a sharp drop to only 17.0%. In July, the occurrence of advanced stages increased somewhat to 34.2% to create a second smaller spawning peak before again declining in August to 26.9%. By September, most spawning activity was complete as only 6.8% of the females showed advanced development. From October through March advanced ovarian development was rare, but two stage V females (3.0%) were collected in November, and one stage IV female was found in January (1.0%).

During the study period, salinities ranged as high as 36 parts per thousand in inland waters, and water temperatures ranged from 7° to 33°C

Table 35. Number of spotted seatrout, *Cynoscion nebulosus*, collected by month, sex and reproductive stage for the period January 1979 through June 1982.

	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
Month	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	64	82	29	7	6	0	1	1						
February	93	70	17	0	2	0								
March	95	53	14	0	1	0								
April	49	50	21	13	9	1			7	0	1	0	1	0
May	2	20	32	21	30	5	6	2	30	0	13	0		
June	4	19	36	10	9	0	4	0	4	0	1	0	1	0
July	6	13	15	3	4	3	4	0	8	0			1	0
August	5	11	12	0	2	0	3	0	4	0				
September	26	13	12	4	3	0	2	0	1	0				
October	46	13	4	0										
November	54	16	9	0	1	0			2	0				
December	61	25	4	0	1	0								

throughout the year with an average monthly temperature of 21°C. Bimonthly water temperatures and salinities are shown in Tables 36 and 37.

As spawning activity commenced in April, females exhibiting advanced ovarian development were found only in salinities above 26 °/oo (Table 38). In May, the peak month for spawning activity, advanced ovarian development was observed in salinities ranging from 11 to 36 °/oo. Nearly half (43.4%) of the May females exhibited advanced ovarian development. Furthermore, there was a definite increase in the occurrence of advanced stages with each five part increase in salinity levels. These increases were as follows: 11-15 °/oo (23.1%), 16-20 °/oo (29.6%), 21-25 °/oo (34.8%), 26-30 °/oo (56.1%), 31-35 °/oo (75.0%) and 36-40 °/oo (100.0%).

Unfortunately, all females collected in June were collected from salinities between 26 and 30 °/oo. Although most of the specimens collected during July and August were collected from salinities greater than 21 °/oo, one July female exhibiting advanced development was taken from salinity less than 15 °/oo. By September, advanced maturity stages were uncommon in all salinity levels, and by October no advanced stages were observed (Table 38).

Table 39 presents the maturity stages for female and male seatrout by water temperature and salinity gradient. Only one female exhibiting advanced ovarian development (stages IV through VII) was collected from water temperatures below 15°C. At water temperatures 16-20°C advanced maturity began to appear when three females (1.9%) exhibited advancement. However, once water temperatures exceeded 21°C the percentage of females exhibiting advanced ovarian development jumped sharply to 22.6% (Table 39). Similar findings were reported in Texas by Simmons (1957) and in Louisiana by Fontenot and Rogillio (1970). Hein and Shepard (1979) related peak spawning to photoperiod in Louisiana. Arnold et al. (1976) found that trout spawn in the laboratory over a salinity range of 26-30 °/oo at 26°C and 15 hours light. Taniguchi (1980) found that optimum temperature and salinity in laboratory experiments were 28.0°C and 28.1 °/oo, respectively.

When viewed according to salinity level or gradient, the occurrence of advanced stages generally increased with the increase in salinity

Table 36. Average surface water temperatures (^{o}C) by sector and month in bi-monthly increments for Glynn County, Georgia from January 1979 through June 1982.

	AVERAGE SURFACE WATER TEMP. (^{o}C)											
	CREEKS			SOUNDS			BEACHES			AREAS COMBINED		
MONTH	Days 1-15	Days 16-31	Monthly Average	Days 1-15	Days 16-31	Monthly Average	Days 1-15	Days 16-31	Monthly Average	Days 1-15	Days 16-31	Monthly Average
January	11.6	11.8	11.7	11.0	10.6	10.8	12.0	8.0	10.0	11.4	11.2	11.3
February	10.3	13.3	11.8	14.1	12.8	13.5	10.0	15.0	12.5	11.6	13.2	12.4
March	14.9	18.6	16.7	13.7	17.2	15.6	16.0	16.1	16.1	14.6	17.8	16.2
April	20.7	22.8	21.8	19.5	22.4	21.0	19.5	24.0	21.8	20.0	22.7	21.4
May	23.7	26.2	25.0	23.3	25.7	24.5	24.5	25.6	25.1	23.6	25.9	24.8
June	27.2	28.5	27.9	28.5	29.0	28.8	30.0	28.0	29.0	27.6	28.8	28.2
July	29.3	29.8	29.6	29.2	29.8	29.5	30.0	30.3	30.2	29.2	29.8	29.5
August	30.6	29.7	30.2	30.7	28.9	29.8	30.0	29.5	29.8	30.7	29.1	29.9
September	29.0	27.1	28.1	28.4	27.0	27.7	28.7	27.7	28.2	28.6	27.4	28.0
October	24.4	22.1	23.3	25.2	22.9	24.1	25.7	23.3	24.5	24.8	22.7	23.8
November	20.0	16.4	18.2	20.1	16.7	18.4	21.0	19.5	20.3	20.1	16.7	18.4
December	15.0	11.9	13.5	14.8	11.3	13.1	15.0	10.0	12.5	14.9	12.3	13.6

Table 37. Average surface water salinities ($^{o}/oo$) by sector and month in bi-monthly increments for the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

	AVERAGE SURFACE WATER SALINITY ($^{o}/oo$)											
	CREEKS			SOUNDS			BEACHES			AREAS COMBINED		
MONTH	Day 1-15	Day 16-31	Combined Average	Day 1-15	Day 16-31	Combined Average	Day 1-15	Day 16-31	Combined Average	Day 1-15	Day 16-31	Combined Average
January	23.8	22.5	23.2	27.2	21.8	24.5	28.0	27.0	27.5	25.3	22.2	23.7
February	21.6	19.6	20.6	22.1	21.9	22.0	24.3	25.1	24.7	22.7	22.2	22.4
March	18.3	18.3	18.3	19.6	18.8	19.2	28.0	24.6	26.3	19.7	18.9	19.3
April	19.4	17.7	18.6	21.1	20.2	20.6	25.0	28.5	26.7	20.5	18.6	19.5
May	22.5	22.2	22.4	23.6	24.1	23.8	28.2	26.8	27.5	24.2	23.5	23.8
June	23.5	26.1	24.8	28.5	30.4	29.4	34.7	27.6	31.2	28.9	28.7	28.8
July	26.3	29.2	27.8	29.3	27.8	28.6	30.0	31.9	31.0	28.5	29.6	29.1
August	28.1	26.9	27.5	30.2	30.0	30.1	29.5	31.4	30.4	29.1	29.2	29.1
September	24.5	26.8	25.7	26.8	25.3	26.0	31.0	33.5	32.3	27.4	28.5	28.0
October	27.1	25.0	26.1	28.9	25.4	27.1	30.6	31.5	31.1	28.9	27.3	28.1
November	24.5	23.9	24.2	26.0	28.1	27.0	27.0	27.3	27.2	25.5	26.4	26.1
December	23.6	25.2	24.4	27.8	28.2	28.0	28.5	31.0	29.8	26.6	28.1	27.4

Table 38. Stages of gonadal development for spotted seatrout, *Cynoscion nebulosus*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Month	Reproductive Stage	Surface Water Salinity (0/00) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	36-40 F	36-40 M	Totals F	Totals M
January	I	-	-	-	-	-	-	2	16	50	28	12	37	0	1	-	-	64	82
	II	-	-	-	-	-	-	3	2	10	1	11	4	5	0	-	-	29	7
	III	-	-	-	-	-	-	2	0	-	-	4	0	-	-	-	-	6	0
	IV	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1
	V-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I	2	1	12	9	6	8	36	20	8	7	29	25	-	-	-	-	93	70
	II	-	-	4	0	1	0	4	0	5	0	3	0	-	-	-	-	17	0
	III	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I	-	-	4	1	10	5	26	17	46	28	9	2	-	-	-	-	95	53
	II	1	0	-	-	2	0	5	0	6	0	-	-	-	-	-	-	14	0
	III	-	-	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	3	0	8	8	6	5	12	7	21	13	1	7	1	7	-	-	52	47
	II	-	-	8	2	2	2	3	2	4	2	1	3	3	2	-	-	21	13
	III	-	-	4	0	-	-	1	0	3	1	-	-	1	0	-	-	9	1
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	4	0	3	0	-	-	7	0
	VI	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
May	I	-	-	-	-	0	3	2	9	0	2	0	6	-	-	-	-	2	20
	II	-	-	-	-	5	1	10	3	7	7	10	10	-	-	-	-	32	21
	III	-	-	-	-	5	2	7	0	8	0	8	2	2	1	-	-	30	5
	IV	-	-	-	-	-	-	2	1	1	0	1	1	2	0	-	-	6	2
	V	-	-	-	-	2	0	4	0	4	0	15	0	4	0	1	0	30	0
	VI	-	-	-	-	1	0	2	0	3	0	7	0	-	-	-	-	13	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	I	-	-	-	-	-	-	-	-	2	8	2	3	0	8	-	-	4	19
	II	-	-	-	-	-	-	-	-	18	5	9	1	9	4	-	-	36	10
	III	-	-	-	-	-	-	-	-	2	0	2	0	5	0	-	-	9	0
	IV	-	-	-	-	-	-	-	-	1	0	1	0	2	0	-	-	4	0
	V	-	-	-	-	-	-	-	-	2	0	1	0	1	0	-	-	4	0
	VI	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	VII	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
July	I	-	-	-	-	-	-	1	0	4	6	1	3	0	4	-	-	6	13
	II	-	-	-	-	-	-	-	-	10	0	3	1	2	2	-	-	15	3
	III	-	-	-	-	-	-	-	-	2	0	2	2	0	1	-	-	4	3
	IV	-	-	-	-	1	0	-	-	1	0	1	0	-	-	-	-	3	0
	V	-	-	-	-	-	-	1	0	3	0	4	0	-	-	-	-	8	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0

Table 38. (continued)

Month	Reproductive Stage	Surface Water Salinity (0/00)																	
		0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		Totals	
		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
August	I	-	-	-	-	-	-	-	-	2	5	1	1	2	5	-	-	5	11
	II	-	-	-	-	-	-	2	0	5	0	3	0	2	0	-	-	12	0
	III	-	-	-	-	-	-	-	-	1	0	1	0	-	-	-	-	2	0
	IV	-	-	-	-	-	-	-	-	2	0	-	-	1	0	-	-	3	0
	V	-	-	-	-	-	-	-	-	1	0	3	0	-	-	-	-	4	0
	VI-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I	-	-	3	1	2	1	3	0	5	4	10	6	3	1	-	-	26	13
	II	-	-	2	0	0	1	-	-	5	1	5	2	-	-	-	-	12	4
	III	-	-	1	0	-	-	-	-	2	0	-	-	-	-	-	-	3	0
	IV	-	-	-	-	-	-	1	0	1	0	-	-	-	-	-	-	2	0
	V	-	-	1	0	-	-	-	-	-	-	-	-	-	-	-	-	1	0
	VI-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I	-	-	1	1	-	-	10	2	21	9	13	1	1	0	-	-	46	13
	II	-	-	-	-	-	-	1	0	1	0	1	0	1	0	-	-	4	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I	-	-	-	-	-	-	-	-	33	4	21	12	-	-	-	-	54	16
	II	-	-	-	-	-	-	-	-	5	0	4	0	-	-	-	-	9	0
	III	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	VI-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I	-	-	-	-	-	-	9	1	46	22	5	2	1	0	-	-	61	25
	II	-	-	-	-	-	-	-	-	4	0	-	-	-	-	-	-	4	0
	III	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combined Totals	I	5	1	28	20	24	22	101	72	238	136	104	105	8	26	-	-	508	382
	II	1	0	14	2	10	4	28	7	80	16	50	21	22	8	-	-	205	58
	III	-	-	5	0	5	2	11	0	19	1	20	4	8	2	-	-	68	9
	IV	-	-	-	-	1	0	4	2	6	0	3	1	5	0	-	-	19	3
	V	-	-	1	0	2	0	5	0	10	0	29	0	8	0	1	0	56	0
	VI	-	-	-	-	1	0	2	0	3	0	10	0	-	-	-	-	15	0
	VII	-	-	-	-	-	-	-	-	1	0	-	-	2	0	-	-	3	0

Table 39. Stages of gonadal development for spotted seatrout, *Cynoscion nebulosus*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)	Reproductive Stage	Surface Water Temperature (°C) 0-5		6-10		11-15		16-20		21-25		26-30		31-35		Totals	
		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
	I	-	-	2	1	-	-	3	0	-	-	-	-	-	-	5	1
0-5	II	1	0	-	-	-	-	-	-	-	-	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	12	9	-	-	9	4	4	6	3	1	-	-	28	20
	II	-	-	4	0	-	-	7	2	1	0	2	0	-	-	14	2
	III	-	-	-	-	-	-	4	0	-	-	1	0	-	-	5	0
6-10	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	6	8	2	2	14	9	0	2	1	1	-	-	23	22
	II	-	-	1	0	1	0	2	2	6	1	0	1	-	-	10	4
	III	-	-	-	-	-	-	-	-	5	1	0	1	-	-	5	2
11-15	IV	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	V	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	VI	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	40	29	23	13	8	17	29	13	1	0	-	-	101	72
	II	-	-	6	2	2	0	2	2	16	3	-	-	2	0	28	7
	III	-	-	3	0	-	-	1	0	7	0	-	-	-	-	11	0
16-20	IV	-	-	1	1	-	-	-	-	3	1	-	-	-	-	4	2
	V	-	-	-	-	-	-	-	-	4	0	1	0	-	-	5	0
	VI	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	42	21	74	43	69	26	36	22	16	24	1	0	238	136
	II	-	-	7	1	11	0	12	0	10	8	40	7	-	-	80	16
	III	-	-	-	-	1	0	-	-	5	1	13	0	-	-	19	1
21-25	IV	-	-	-	-	-	-	-	-	-	-	6	0	-	-	6	0
	V	-	-	-	-	-	-	-	-	2	0	8	0	-	-	10	0
	VI	-	-	-	-	-	-	-	-	3	0	-	-	-	-	3	0
	VII	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	I	-	-	20	45	35	20	21	13	14	8	14	18	0	1	104	105
	II	-	-	11	4	3	0	4	0	6	8	24	9	2	0	50	21
	III	-	-	6	0	-	-	1	0	6	1	6	3	1	0	20	4
26-30	IV	-	-	-	-	-	-	-	-	0	1	3	0	-	-	3	1
	V	-	-	-	-	-	-	3	0	9	0	15	0	2	0	29	0
	VI	-	-	-	-	-	-	-	-	7	0	1	0	-	-	8	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	1	1	-	-	-	-	1	7	5	15	1	3	8	26
	II	-	-	5	0	-	-	1	0	3	2	11	6	2	0	22	8
	III	-	-	-	-	-	-	-	-	3	1	5	1	-	-	8	2
31-35	IV	-	-	-	-	-	-	-	-	2	0	3	0	-	-	5	0
	V	-	-	-	-	-	-	-	-	7	0	1	0	-	-	8	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	1	0	1	0	-	-	2	0
	I-IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36-40	V	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	123	114	134	78	124	69	84	58	40	59	2	4	507	382
	II	1	0	34	7	17	0	28	6	42	22	78	23	6	0	206	58
	III	-	-	9	0	1	0	6	0	26	4	25	5	1	0	68	9
TOTALS	IV	-	-	1	1	-	-	-	-	5	2	13	0	-	-	19	3
	V	-	-	-	-	-	-	3	0	24	0	27	0	2	0	56	0
	VI	-	-	-	-	-	-	-	-	14	0	1	0	-	-	14	0
	VII	-	-	-	-	-	-	-	-	1	0	2	0	-	-	3	0

(Table 39). No advanced stages were observed at salinity levels <5 $^{o}/oo$. Only 6% of all females collected from salinities <25 $^{o}/oo$ exhibited advanced ovarian development with no more than 10% occurrence in any lower salinity gradient. However, at salinities of 26-30 $^{o}/oo$ the occurrence of advanced ovarian development jumped sharply to 18.7%, and at salinities above 31 $^{o}/oo$ the percentage jumped to 29.6%.

From the figures presented above it is evident that peak spawning takes place at temperatures above 21^{o}C and salinities above 26 $^{o}/oo$. It is logical to conclude, therefore, that maximum spawning activity in Georgia takes place in the higher salinity waters of the lower sounds and along the beaches where salinities exceed 25 $^{o}/oo$ once the water temperature exceeds 21^{o}C. These conclusions are supported by similar findings reported previously in Georgia by Mahood (1975). In addition, large catches of "roe" trout by recreational fishermen during May and June in the sounds and along the beaches further substantiate these findings. Since Georgia's sounds are relatively small, spawning activity in these areas would be in close proximity to the beaches and the higher salinity waters.

Table 40 presents a description of spawning activity, through the occurrence of advanced ovarian development, for female seatrout according to lunar phases. When viewed according to lunar phase, little variation in spawning activity was found. When advanced stages of female seatrout were grouped by moon phase the percentages were: new moon, 22.1%; first quarter, 14.7%; full moon, 28.4%; last quarter, 21.1%; and split phases, 13.7%. Apparently there was more spawning activity during full moon and new moon periods even though advanced stages were encountered throughout the lunar cycle. This may have some significance as full and new moon phases are periods of high tidal amplitude and maximum turbidity which may benefit survival rates. Adkins et al, 1979 (Cited in: Adkins and Bourgeois, 1982) reported that a sharp increase of gravid females occurred shortly before each full moon and that spent females were found shortly after the full moon in Louisiana. Our data also show some variation according to lunar phase, but the difference is not strongly pronounced.

Table 40. Number and percent of fish showing advanced gonadal development during various moon phases by species and sex for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Species Reproduction Stages		MOON PHASE																											
		3 Days Prior		New Moon		3 Days After		3 Days Prior		Last Quarter		3 Days After		3 Days Prior		Full Moon		3 Days After		3 Days Prior		Last Quarter		3 Days After		Split Phases		Combined Totals	
		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Spotted seatrout	No. examined	127	53	48	26	34	8	76	42	22	17	33	19	67	57	21	7	121	58	98	42	5	6	139	70	85	47	876	452
	No. advanced[1/]	18	1	-	-	3	0	5	1	6	0	3	0	10	0	1	0	16	0	10	0	-	-	10	1	13	0	95	3
	Percent	14.2	1.9	-	-	8.8	0.0	6.6	2.4	27.3	0.0	9.1	0.0	14.9	0.0	4.8	0.0	13.2	0.0	10.2	0.0	-	-	7.2	1.4	15.3	0.0	10.6	0.7
Weakfish	No. examined	37	10	0	1	3	1	25	12	7	5	29	1	8	1	19	1	43	2	45	4	1	0	29	5	11	0	257	43
	No. advanced	6	0	-	-	-	-	1	0	-	-	-	-	4	0	-	-	1	1	6	0	-	-	-	-	2	0	20	1
	Percent	16.2	0.0	-	-	-	-	4.0	0.0	-	-	-	-	50.0	0.0	-	-	2.3	50.0	13.3	0.0	-	-	-	-	18.2	0.0	7.8	2.3
Red drum	No. examined	1	1	4	1	-	-	0	6	-	-	3	1	3	4	0	1	4	5	1	2	2	0	0	2	2	3	20	26
	No. advanced	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1	0	1
	Percent	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0	33.3	0.0	3.7
Southern flounder	No. examined	24	2	2	0	3	2	12	5	3	1	10	0	5	0	2	0	7	0	4	0	2	0	16	1	13	0	103	11
	No. advanced	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Percent	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black drum	No. examined	3	2	-	-	0	1	1	1	-	-	2	9	2	1	-	-	4	0	-	-	-	-	2	7	5	3	19	24
	No. advanced	2	0	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	-	-	-	-	-	-	-	-	4	0
	Percent	66.7	0.0	-	-	-	-	-	-	-	-	-	-	100.0	0.0	-	-	-	-	-	-	-	-	-	-	-	-	21.1	0.0
Sheepshead	No. examined	18	11	3	1	2	1	2	0	1	1	1	3	5	1	2	0	7	6	15	8	-	-	2	1	3	3	61	36
	No. advanced	12	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	8
	Percent	66.7	72.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.7	22.2
Atlantic croaker	No. examined	8	4	2	3	2	4	32	3	2	0	18	5	4	0	1	0	7	0	10	8	3	0	23	4	13	3	125	34
	No. advanced	-	-	-	-	-	-	2	0	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	2	0	5	0
	Percent	-	-	-	-	-	-	6.3	0.0	-	-	-	-	-	-	-	-	-	-	10.0	0.0	-	-	-	-	15.4	0.0	4.0	0.0
Spot	No. examined	18	8	-	-	10	12	26	20	2	1	0	3	17	3	10	13	16	9	6	4	2	0	31	15	33	31	171	119
	No. advanced	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Percent	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Southern kingfish	No. examined	15	1	-	-	12	0	9	1	9	1	11	2	3	0	1	1	9	1	32	3	1	0	21	3	15	0	138	13
	No. advanced	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	1	0	3	1
	Percent	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.3	33.3	-	-	-	-	6.7	0.0	2.2	7.7

1/ Advanced reproductive stages include stages IV through VII.

The sex ratios for spotted seatrout by length group in 50 mm groupings appear in Table 41. The overall ratio of female to male seatrout collected during this study was 1.9:1. Ratios for individual length groups showed an increasingly higher ratio of females over males as length increased. In trout <250 mm males outnumbered females with ratios ranging up to 1:3. In specimens 251-350 mm the ratio was nearly equal at 1:1. However, for fish 351-400 mm females became dominant at 2.6:1. The highest ratio of females to males was for fish 501-550 mm with a ratio of 23:1. Female seatrout live longer and attain larger sizes than the males throughout the range (see age and growth section). This accounts for the higher ratio of females to males for the older and larger fish. Furthermore, since males do not generally attain the larger size they are probably more prone to capture by sport fishermen using live shrimp to fish for trout of small to moderate size.

Monthly distribution of seatrout by sex and salinity gradient are presented in Table 42. Females outnumbered males during all months and at all salinity levels. The greatest monthly occurrence of males came during January (47%) and April (40%). The greatest singular concentration of males came during January in salinities of 26-30 $^{o}/oo$ when 41 specimens (60%) were collected. It is felt by the authors that there is probably some seasonal segregation of sexes as recreational fishermen quite often report large catches of predominantly male or female trout. However, these data do not substantiate that view. A comparision of the estuarine distribution of females and males of each fish species is presented by salinity gradient in Table 43.

The general condition of the gonads of spotted seatrout were examined through gross examination and all abnormalities were recorded as fish were examined for life history studies. The number and percent of female seatrout exhibiting various ovarian conditions are presented by estuarine system in Table 44.

Of 788 seatrout ovaries examined, 639 (81.1%) appeared normal in all respects. The most frequently occurring abnormal condition was classified as "resorbing eggs". This condition occurred when females

Table 41. Sex ratio for marine sportfishes in 50 mm length groups for fish collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Sex Ratio and Number in Samples by Species (female:male)								
	Spotted seatrout	Weakfish	Red drum	Southern flounder	Black drum	Sheepshead	Atlantic croaker	Spot	Southern kingfish
1-50							1:0 (1)	1.7:1 (16)	
51-100		0:1 (1)						1:2 (6)	
101-150	0:1 (1)	1:0 (1)		1:0 (1)			1:0 (3)	1:1 (2)	5:1 (6)
151-200	1:1.5 (5)	1:1 (24)		1:0 (2)	1:2 (3)		3.4:1 (48)	1.3:1 (47)	2.8:1 (19)
201-250	1:3 (28)	5.3:1 (38)		3:1 (11)	1:6 (21)	1:1.4 (19)	3.5:1 (50)	1.3:1 (202)	22:1 (46)
251-300	1.2:1 (74)	1.4:1 (34)		3.3:1 (26)	1:1 (6)	1.9:1 (20)	3.4:1 (53)	15:1 (16)	15:1 (32)
301-350	1:1 (472)	9.5:1 (84)	1:2 (3)	26:1 (27)	1:1 (2)	5:1 (12)	1:0 (3)	0:1 (1)	19:1 (40)
351-400	2.6:1 (458)	47:1 (96)	1:6 (7)	16:1 (17)	1:1 (2)	7:1 (8)	1:0 (1)		6:1 (7)
401-450	6.8:1 (132)	1:0 (18)	1:2.7 (11)	1:0 (7)	1:2 (3)	1:1.2 (11)			1:0 (1)
451-500	6:1 (70)	1:0 (1)		1:0 (10)	1:1 (2)	1.6:1 (13)			
501-550	23:1 (48)	1:0 (1)	4:1 (5)	1:0 (6)		1.7:1 (8)			
551-600	15:1 (32)	1:0 (1)	1:3 (4)	1:0 (3)	1:0 (1)	5:1 (6)			
601-650	1:0 (6)		1:0 (4)	1:0 (3)					
651-700	1:0 (1)		1:2 (3)	1:0 (2)					
701-750	1:0 (1)		1:1.5 (5)		1:0 (1)				
751-800			1:2 (3)						
801-850									
851-900					1:0 (1)				
901-950					(1)				
951-1000									
1001-1050									
1051-1100			1:0 (2)						
1101-1150					1:0 (2)				
1151-1200					1:0 (2)				
COMBINED	1.9:1 (1328)	6:1 (299)	1:1.3 (47)	9.5:1 (116)	1:1.5 (47)	1.7:1 (97)	3.7:1 (159)	1.4:1 (290)	10.6:1 (151)

NOTE: Value within parentheses is the number of fish in sample.

Table 42. Number and percent of female versus male spotted seatrout, *Cynoscion nebulosus*, by salinity gradient and month for *fish collected in Glynn County, Georgia from January 1979 through June 1982.*

		SURFACE WATER SALINITY (0/00)																	
		0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		TOTAL	
MONTH		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	No.							8	19	60	29	27	41	5	1			100	90
	%							30	70	67	33	40	60	83	17			53	47
February	No.	2	1	16	9	7	8	40	20	13	7	34	25	0	8			112	70
	%	67	33	64	36	47	53	67	33	65	35	58	42	0	100			62	38
March	No.	1	0	4	1	12	5	32	17	52	28	9	2					110	53
	%	100	0	80	20	71	29	65	35	65	35	82	18					67	33
April	No.	3	0	20	10	8	7	16	9	28	16	7	10	9	9			91	61
	%	100	0	67	33	53	7	64	36	64	36	41	59	50	50			60	40
May	No.					13	6	27	13	23	9	41	19	8	1	1	0	113	48
	%					68	32	68	32	72	28	68	32	89	11	100	0	70	30
June	No.									26	13	16	4	17	12			59	29
	%									67	33	80	20	59	41			67	33
July	No.					1	0	2	0	20	6	11	6	3	7			37	19
	%					100	0	100	0	77	23	65	35	30	70			66	34
August	No.							2	0	11	5	8	1	5	5			26	11
	%							100	0	69	31	89	11	50	50			70	30
September	No.			7	1	2	2	4	0	13	5	15	8	3	1			44	17
	%			88	12	50	50	100	0	72	18	65	35	75	25			72	28
October	No.			1	1			11	2	22	9	14	1	2	0			50	13
	%			50	50			85	15	71	29	93	7	100	0			79	21
November	No.									38	4	28	12					66	16
	%									90	10	70	30					80	20
December	No.							9	1	51	22	5	2	1	0			66	25
	%							90	10	70	30	71	29	100	0			73	27
TOTALS	No.	6	1	48	22	43	28	151	81	357	153	215	131	53	36	1	0	874	452
	%	86	14	69	31	61	39	65	35	70	30	62	38	60	40	100	0	66	34

Table 43. Number and percent of females versus males by salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

		SURFACE WATER SALINITY (°/oo)																	
		0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		TOTAL	
SPECIES		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Spotted seatrout	No.	6	1	48	22	43	28	151	81	357	153	215	131	53	36	1	0	874	452
	%	85.7	14.3	68.6	31.4	60.6	39.4	65.1	34.9	70.0	30.0	62.2	37.8	59.5	40.5	100.0	0.0	65.9	34.1
Weakfish	No.	-	-	-	-	4	0	58	7	55	14	88	11	52	11	-	-	257	43
	%	-	-	-	-	100.0	0.0	89.2	10.8	79.7	20.3	88.9	11.1	82.5	17.5	-	-	85.7	14.3
Red drum	No.	1	0	-	-	0	1	6	5	6	5	4	11	3	5	-	-	20	27
	%	100.0	0.0	-	-	0.0	100.0	54.5	45.5	54.5	45.5	26.7	73.3	37.5	62.5	-	-	42.6	57.4
Southern flounder	No.	-	-	-	-	3	0	9	6	29	2	40	2	21	1	-	-	102	11
	%	-	-	-	-	100.0	0.0	60.0	40.0	93.5	6.5	95.2	4.8	95.5	4.5	-	-	90.3	9.7
Summer flounder	No.	-	-	-	-	-	-	-	-	-	-	2	0	1	0	-	-	3	0
	%	-	-	-	-	-	-	-	-	-	-	100.0	0.0	100.0	0.0	-	-	100.0	0.0
Black drum	No.	-	-	1	9	0	2	2	7	6	3	3	5	3	2	-	-	15	28
	%	-	-	10.0	90.0	0.0	100.0	22.2	53.8	46.2	37.5	37.5	62.5	60.0	40.0	-	-	34.9	65.1
Sheepshead	No.	-	-	-	-	5	6	2	0	24	8	10	7	6	4	14	12	61	37
	%	-	-	-	-	45.5	54.5	100.0	0.0	75.0	25.0	58.8	41.2	60.0	40.0	53.8	46.2	62.9	37.1
Atlantic croaker	No.	-	-	1	0	4	1	27	7	24	12	55	13	15	2	-	-	127	35
	%	-	-	100.0	0.0	80.0	20.0	79.4	20.6	66.7	33.3	80.9	19.1	88.2	11.8	-	-	78.4	21.6
Spot	No.	-	-	2	1	13	7	11	13	65	68	48	27	27	2	-	-	166	118
	%	-	-	66.7	33.3	65.0	35.0	45.8	54.2	48.9	51.1	64.0	36.0	93.1	6.9	-	-	58.5	41.5
Southern kingfish	No.	-	-	1	0	1	0	10	0	25	8	38	2	62	4	-	-	138	14
	%	-	-	100.0	0.0	100.0	0.0	100.0	0.0	75.7	24.3	95.0	5.0	94.0	6.0	-	-	90.1	9.9
Gulf kingfish	No.	-	-	-	-	-	-	-	-	3	2	1	0	29	2	-	-	33	4
	%	-	-	-	-	-	-	-	-	33.3	66.7	100.0	0.0	93.8	6.3	-	-	89.2	10.8

Table 44. Number and percent of various ovarian conditions for spotted seatrout, *Cynoscion nebulosus*, by estuarine system for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	St. Simons		St. Andrew		Altamaha		Combined	
Ovarian Condition	No.	%	No.	%	No.	%	No.	%
Normal	414	80.7	220	81.8	5	83.3	639	81.1
Resorbing eggs	33	6.4	24	8.9	1	16.7	58	7.4
Atypical ovaries	35	6.8	16	5.9	-	-	51	5.7
Atrophic ovaries	6	1.2	2	0.7	-	-	8	1.0
Unequal development	8	1.6	1	0.4	-	-	9	1.1
Fragmented ovaries	7	1.4	3	1.1	-	-	10	1.3
Fluid laden ovaries	2	0.4	-	-	-	-	2	0.3
Missing oviducts	1	0.2	-	-	-	-	1	0.1
*Missing gonads	1	0.2	1	0.4	-	-	2	0.3
Hermaphroditic gonads	6	1.2	2	0.7	-	-	8	1.0
TOTAL EXAMINED	513	100.0	269	100.0	6	100.0	788	100.0

* Adult size fish with no gonads present.
NOTE: Ovarian conditions were determined by gross examination.

failed to spawn their eggs and were physiologically trying to resorb the egg masses. This condition occurred in 7.4% of the ovaries examined. In most of these fish the ovaries appeared to be cystic and contained large hard lumps of degenerative egg mass which quite often appeared to be so severe as to result in permanent sterility (Figure 17). Whether this condition was the result of malfunction or disease is unknown. Further studies should be conducted on this particular anomaly and its causes.

"Atypical ovaries" included a variety of other conditions in which the ovaries did not conform to the normal shape, size and color, and included ovaries that had become fused with other organs or mesentery. This condition was found in 5.7% of those examined. "Unequal development" between the paired ovaries of an individual fish was encountered in 1.1%, and was usually seen as only partial development in one ovary while the other ovary was in an easily recognized stage of ovarian development (Figure 18). "Fragmented ovaries" represented 1.3% and were typified by one or both ovaries being in two or more parts. Two adult size seatrout were found with no apparent gonads and were included herein. This condition occurred in only 0.3% of those examined.

The most significant single sexual anomaly encountered during this study was the presence of eight hermaphroditic seatrout exhibiting various degrees of hermaphroditism (Figures 19 and 20). This condition was found in only 1.0% of the fish examined and the particular gonads exhibiting this condition were generally dominated by ovarian tissue. One fish, however, exhibited approximately 75% of each gonad being testes and 25% ovary, and both eggs and milt were clearly visible in the separate portions of each gonad (Figure 19). The two portions of each lobe of these hermaphroditic gonads were fused together. The gonads of other specimens in hermaphroditic condition were composed of primarily ovarian tissue which comprised over 75% of one or both gonads (Figure 20).

A comparison of the frequency of occurrence for each type sexual anomaly within each estuarine system revealed less than 3% difference

Figure 17. Cystic condition observed in spotted seatrout ovaries that failed to resorb the egg mass.

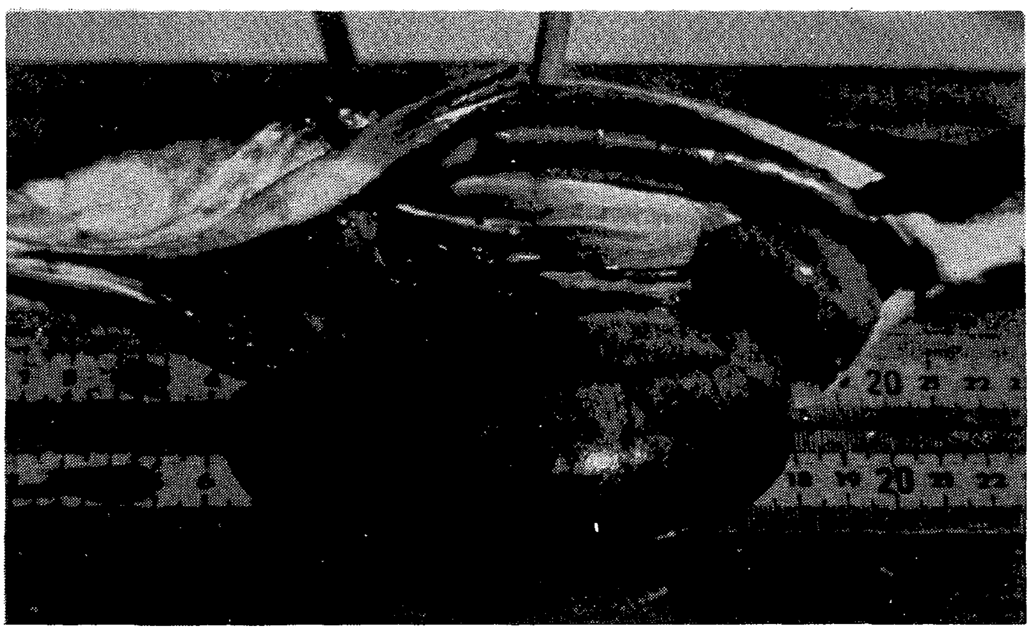


Figure 18. Spotted seatrout ovaries exhibiting unequal development and fluid laden ovaries.

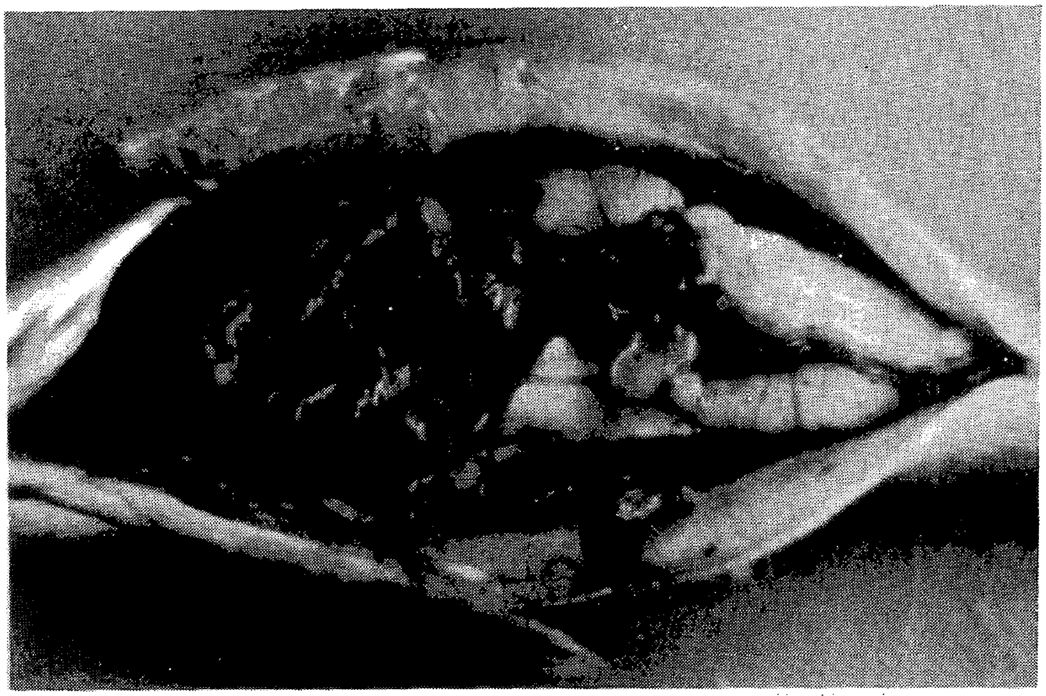


Figure 19. Hermaphroditic spotted seatrout with gonads consisting primarily of testicular tissue.

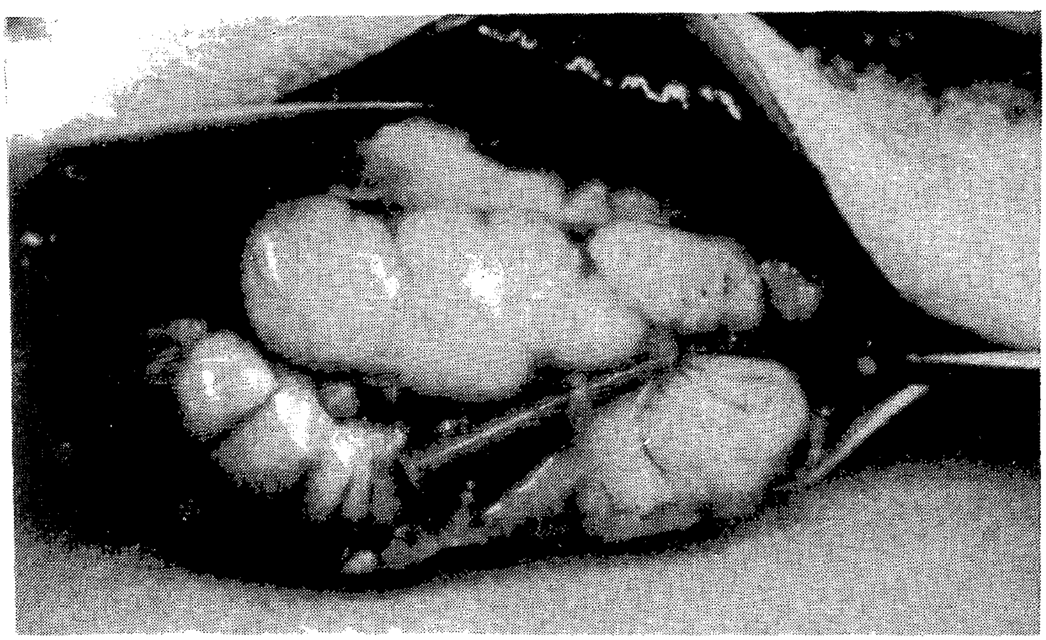


Figure 20. Hermaphroditic spotted seatrout with gonads consisting primarily of ovarian tissue.

in occurrence between the St. Simons and St. Andrew estuarine systems. No comparison is given for the Altamaha system as sample size was too small (Table 44).

Fecundity of the spotted seatrout in the Gulf of Mexico was reported in Texas by Pearson (1929) and Miles (1950), in west Florida by Moody (1950), and in Louisiana by Sundararaj and Suttkus (1962). However, comparatively limited information has been published for seatrout fecundity on the Atlantic coast. Fecundity for seatrout collected in the Indian River area of east-central Florida was investigated by Tabb (1961). In general, fecundity estimates reported by the various investigations ranged from 15 thousand to 1.1 million eggs for spotted seatrout ranging from 283 to 625 mm (TL). Fecundity for several seatrout populations is illustrated in Figure 21.

Fecundity estimates were determined for 12 Georgia spotted seatrout ranging in length, weight, and age from 325 to 533 mm, 386 to 1,871 g, and III to V years. The mean estimated fecundity was 245,990 eggs with a range from 107,300 to 468,200 eggs. Fecundity data for these 12 seatrout are shown in Table 45.

Food Preference and Feeding Habits

The spotted seatrout is considered by many to be the most popular inshore sportfish from South Carolina to Texas, and has been the target of intensive investigations, including its feeding habits. Most workers agree that trout are opportunistic feeders whose food habits change with size and age (Moody, 1950; Simmons, 1957; Seagal, 1969; Peret et al., 1980). In general, the primary food for young trout is crustaceans. However, there is a general shift with age from smaller crustaceans such as copepods in the juveniles to larger commercial penaeid shrimp in small to medium sized adults. In the largest adults the diet shifts from crustaceans to primarily fishes.

Pearson (1929) reported that Texas seatrout feed primarily on shrimp, and similar findings were reported by Kemp (1949), Stewart (1961) and McHugh (1980). Lorio and Schafer (1966) reported that fish were the most important food for adult Louisiana seatrout, but crustaceans were

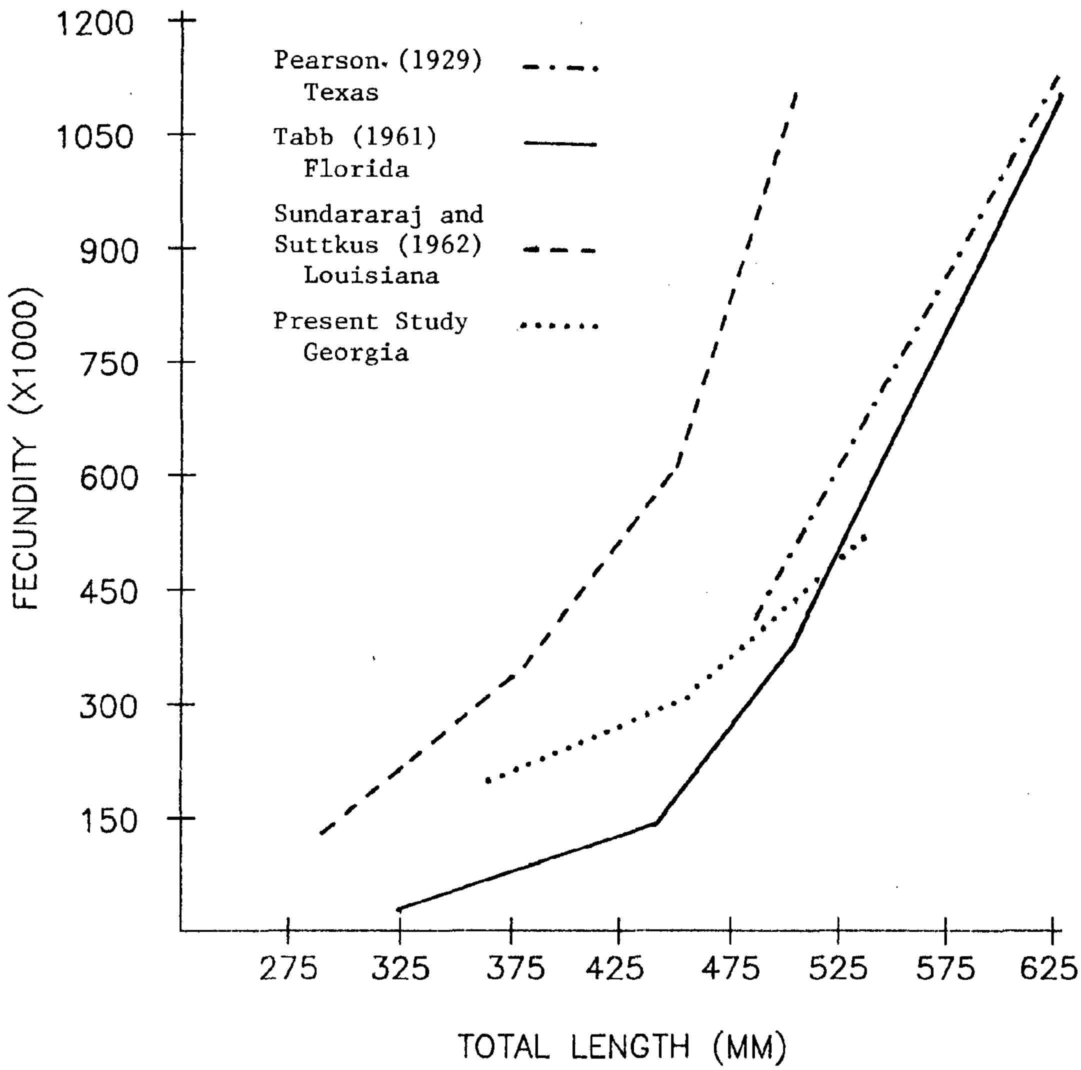


Figure 21. Comparison of fecundity for several populations of spotted seatrout, *Cynoscion nebulosus*.

Table 45. Estimated fecundity for 12 spotted seatrout, *Cynoscion nebulosus*, collected in the coastal waters of Glynn County, Georgia during May and June of 1980.

Year Class	Number of Fish	Total Length (mm) Mean	Total Length (mm) Range	Mean Fish Weight (g)	Percent Gonad Weight	Estimated Fecundity (X1000) Mean	Estimated Fecundity (X1000) Range
III	8	362	325 - 396	588	15.3	192.5	108.2 - 298.6
IV	3	453	419 - 491	1,120	11.1	277.2	167.9 - 433.8
V	1	533	533	1,871	16.3	468.2	468.2
Combined	12	398	225 - 533	828	14.1	246.0	108.2 - 468.2

equally important from May through July. Gunter (1945) reported that seatrout feed primarily on fish during winter in Texas. Brewer (1957) reported mullet and silversides as the top foods in Baffin Bay, Texas where shrimp are not abundant. Moody (1950) reported that seatrout feeding habits progressed through four stages from copepods to caridean shrimp to penaeid shrimp to fish in Cedar Key, Florida. Tabb (1961) suggested that food selectivity by adult seatrout in east-central Florida was more a function of food availability than selectivity. Seagle (1969) found that trout over 350 mm fed mainly on fish. Mahood (1974) reported that Georgia seatrout appeared to have no definite preference and ate whatever was easiest to attain at different times of the year.

From the findings of these other workers and from the results of this study it appears that spotted seatrout feed on the most available and easiest foods to attain. This is substantiated by Georgia anglers taking trout on live shrimp during warmer months from May through November and even into December when penaeid shrimp are available. As water temperatures drop sharply in December, penaeid shrimp become less abundant as they migrate offshore and southward. During winter most anglers shift to artificial lures to catch seatrout as small fish become the most available food source. Our findings from stomach analyses of seatrout collected during this study are presented below.

Of the 1,359 spotted seatrout stomachs examined during this study, 874 (64.3%) contained food and 485 (35.7%) were empty (Table 46). Food items identified in the stomachs of seatrout per 100 mm length group are presented in Table 47. In juvenile seatrout (<200 mm) the most commonly occurring food source was crustaceans of which grass shrimp (*Palemonetes* sp.) occurred most frequently. As seatrout increased in size, they began to feed more frequently on fish as evidenced by the increasingly higher occurrence of fish in the stomachs of creel size specimens (301-500 mm). In this size group menhaden (*Brevoortia* sp.) were the most frequently ingested species of fish, and white shrimp (*Penaeus setiferus*) were the most commonly observed crustacean. After seatrout reached 600 mm, their feeding habits apparently changed

Table 46. Number and percent of empty stomachs versus those containing food for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Empty Stomachs		Contain Food		Total Stomachs	
	No.	%	No.	%	No.	%
Spotted seatrout	485	35.7	874	64.3	1,359	100.0
Weakfish	86	26.4	240	73.6	326	100.0
Red drum	22	23.4	72	76.6	94	100.0
Southern flounder	108	48.9	113	51.1	221	100.0
Summer flounder	4	14.8	23	85.2	27	100.0
Black drum	15	19.5	62	80.5	77	100.0
Sheepshead	15	12.8	102	87.2	117	100.0
Atlantic croaker	31	11.6	236	88.4	267	100.0
Spot	39	12.1	282	87.9	321	100.0
Southern kingfish	38	16.8	188	83.2	226	100.0
Gulf kingfish	7	20.0	28	80.0	35	100.0

Table 47. Stomach contents of Spotted seatrout, *Cynoscion nebulosus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group (mm) 1-100	101-200	201-300	301-400	401-500	501-600	601-700	701-800	Combined	Percent Occurrence	Average % Bolus
PISCES											
Pisces (unidentifiable)		4	27	253	59	19	2	1	365	41.8	76
Anchoa hepsetus				1					1	0.1	30
Anchoa mitchilli			2	6	1				9	1.0	66
Brevoortia tyrannus			10	119	30	16	1		176	20.1	87
Chloroscombrus chrysurus				1	1				2	0.2	90
Cynoscion nebulosus				1					1	0.1	90
Cyprinodon variegatus				1					1	0.1	30
Fundulus heteroclitus			5	11	1				17	1.9	82
Leiostomus xanthurus			1		1	2			4	0.4	90
Menidia menidia				10	1				11	1.3	82
Menticirrhus americanus				1					1	0.1	90
Mugil cephalus				7	6	6	1		20	1.0	88
Opsanus tau					1				1	2.3	70
Paralichthys lethostigma				1					1	0.1	90
Sciaenops ocellatus				7	1	1			9	0.1	83
Stellifer lanceolatus			1	18	1				20	2.3	85
Symphurus plagiusa				1					1	0.1	90
Syngnathidae				2					2	0.2	30

Table 47. (continued)

Food Item	Length Group (mm) 1-100	101-200	201-300	301-400	401-500	501-600	601-700	701-800	Combined	Percent Occurrence	Average % Bolus
ARTHROPODA											
Crustacea (unidentifiable)		4	9	59	7	1			80	9.2	60
Alpheus heterochelis		1	1	18	5	1			26	3.0	64
Amphipoda				2					2	0.2	<10
Anthuridae				3	2	1			6	0.7	43
Arenaeus cribrarius					2				2	0.2	<5
Athropoda				2					2	0.2	45
Copepoda				2					2	0.2	45
Crangon septemspinosa				1					1	0.1	<5
Cyathura polita			2	2	1				5	0.6	40
Decapoda	1	1	5	38	3	1			49	5.6	76
Diastylidae				1					1	0.1	<5
Gammarus mucronatus				1					1	0.1	<10
Insecta				1					1	0.1	10
Isopoda				3	8				11	1.3	16
Neomysis americana		1		10					11	1.3	55
Ovalipes ocellatus				1					1	0.1	70
Oxyurostylis smithi			1						1	0.1	10
Pagurus longicarpus			1	3					4	0.4	43
Palaemonetes sp.		10	4	47	4	1			66	7.6	68
Penaeidae			3	27	2	1			33	3.8	63
Penaeus aztecus			2	2					4	0.4	55
Penaeus duorarum			1	1	1				3	0.3	50
Penaeus setiferus			3	57	3				63	7.2	80
Sesarma cinereum			1						1	0.1	90
Sicyonia sp.				1					1	0.1	20
Trachypeneus constrictus			1	10	1				12	1.4	68
Uca pugnax						1			1	0.1	10

Table 47. (continued)

Food Item	Length Group (mm) 1-100	101-200	201-300	301-400	401-500	501-600	601-700	701-800	Combined	Percent Occurrence	Average % Bolus
MOLLUSCA											
Mollusca (unidentifiable)					1				1	0.1	50
Crassostrea virginica				1					1	0.1	10
Gastropoda				1					1	0.1	90
CEPHALOPODA											
Cephalopoda (unidentifiable)				4	2				6	0.7	42
Lolliguncula brevis				10	1				11	1.3	54
ANNELIDA and ASCHELMENTHES											
Aegothoa sp.				2					2	0.2	10
Glyceridae				1					1	0.1	90
Glycindae solitaria				1					1	0.1	90
Nematoda				2					2	0.2	<5
Nereidae				1					1	0.1	90
Nicolea simplex				3	1				4	0.4	35
Rhynchocela				4					4	0.4	28
PLANT											
Detritus		1		4	1				6	0.6	50
Spartina alterniflora			2	6	4				12	1.4	58
CNIDARIA											
Anthozoa				1					1	0.1	<5
UROCHORDATA											
Molgula manhattensis				1					1	0.1	<5
INORGANIC MATERIAL		2	1	11					14	1.5	65
ANIMAL TISSUE (unidentifiable)				1					1	0.1	90

Number of stomachs: 1359
Number and percent of stomachs containing food: 874 (64.3%)
Number and percent of empty stomachs: 485 (35.7%)

to a purely piscivorous diet. Similar results were found in Laguna Madre, Texas by Simmons (1957). The preference of fish in the stomachs of large adults accounts for the relatively low number of large trout in daily creels because the preferred bait by Georgia anglers is live penaeid shrimp.

All species of fish identified in stomach contents comprised over 66% of the average food bolus except for *Anchoa hepsetus*, *Cyprinodon variegatus*, and pipefish (*Syngnathus* sp.). The relatively small size of these three species probably accounts for their low contribution to average percent of bolus. Penaeid shrimp were the most frequently occurring crustacean, averaging 50% of food bolus when encountered (Table 47). Penaeids are the largest commonly occurring shrimp in Georgia waters, which would account for this high percent of bolus.

The 10 most frequently occurring food items by season and sector are presented in Table 48. Fish and fish parts were the most commonly encountered food items in trout stomachs in all seasons and sectors and menhaden were the most frequently occurring species. The most commonly ingested crustacean during winter and spring was grass shrimp (*Palaemonetes* sp.), but during summer and fall, white shrimp (*Penaeus setiferus*) became dominant. Furthermore, during fall white shrimp were observed in the stomachs even more frequently than menhaden.

It has been determined in other studies that it takes four to five hours for sea catfish (*Arius felis*) and Atlantic croaker (*Micropogonias undulatus*) to digest brown shrimp (*Penaeus aztecus*) to an unrecognizable state (Divita et al., 1981: Cited in Creel and Divita, 1982). It was also determined that total digestion of mullet by spotted seatrout could take from two to three days (Guest and Gunter, 1958). DeCiechomski (1981) conducted controlled laboratory experiments on the digestion rates of shrimp in juvenile sciaenids off Argentina and found that 32-38% of the food (shrimp) was evacuated from the stomach after 4 to 6 hours from meal ingestion and after 14 hours the percentage jumped to 87%. Assuming that digestion rates for seatrout are comparable with that of sea catfish and croakers and other sciaenids, it would require only a matter of hours to digest shrimp to an unrecognizable state as

Table 48. The 10 most frequently occurring food items found in the stomachs of spotted seatrout, *Cynoscion nebulosus*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Winter				Spring				Summer			
Sector	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus
Creeks	Pisces	73	38.2	80	Pisces	65	47.8	78	Pisces	17	53.1	62
	Brevoortia tyrannus	36	18.8	87	*Brevoortia tyrannus*	52	38.2	85	*Brevoortia tyrannus*	15	46.9	90
	Natantia	23	12.0	79	*Palaemonetes* sp.	11	8.1	61	Crustacea	12	37.5	52
	Crustacea	15	7.9	67	Crustacea	10	7.4	48	*Penaeus setiferus*	7	21.9	54
	Penaeus setiferus	12	6.3	88	Decapoda	6	4.4	40	Penaeidae	7	21.9	50
	Alpheus armilletus	11	5.8	60	*Alpheus armilletus*	4	2.9	65	*Mugil cephalus*	5	15.6	84
	Palaemonetes sp.	10	5.2	77	*Fundulus heteroclitus*	3	2.2	73	*Fundulus heteroclitus*	4	12.5	90
	Penaeidae	7	3.7	60	*Penaeus setiferus*	3	2.2	63	*Penaeus duorarum*	3	9.4	50
	Stellifer lanceolatus	7	3.7	80	Unidentified material	3	2.2	47	*Spartina alterniflora*	3	9.4	40
	Mugil cephalus	4	2.1	90	Isopoda	3	2.2	43	*Cyathura polita*	3	9.4	33
Sounds	Pisces	34	32.1	84	Pisces	51	51.0	72	Pisces	11	34.4	40
	Palaemonetes sp.	27	25.5	79	*Brevoortia tyrannus*	27	27.0	88	*Brevoortia tyrannus*	6	18.8	90
	Natantia	16	15.1	70	Crustacea	9	9.0	63	*Penaeus setiferus*	6	18.8	87
	Decapoda	13	12.3	85	*Menidia menidia*	7	7.0	77	*Fundulus heteroclitus*	4	12.5	75
	Mysidae	9	8.5	67	*Palaemonetes* sp.	6	6.0	62	Isopoda	3	9.4	7
	Alpheus heterochelis	7	6.6	77	*Spartina alterniflora*	4	4.0	73	*Mugil cephalus*	2	6.3	90
	Unidentified material	4	3.8	68	*Stellifer lanceolatus*	2	2.0	90	*Lolliguncula brevis*	2	6.3	70
	Brevoortia tyrannus	3	2.8	90	Cephalopoda	2	2.0	90	*Palaemonetes* sp.	2	6.3	60
	Stellifer lanceolatus	3	2.8	90	Decapoda	2	2.0	75	*Stellifer lanceolatus*	1	3.1	90
	Menidia menidia	1	0.9	90	*Lolliguncula brevis*	2	2.0	50	Penaeidae	1	3.1	90
Beaches	Pisces	2	100.0	50	Pisces	41	68.3	86	*Stellifer lanceolatus*	8	36.4	86
	Brevoortia tyrannus	1	50.0	100	*Brevoortia tyrannus*	10	16.7	90	Pisces	8	36.4	43
					Palaemonetes sp.	5	8.3	40	*Brevoortia tyrannus*	2	9.1	90
					Anchoa mitchelli	4	6.7	70	*Anchoa mitchelli*	1	4.5	90
					Stellifer lanceolatus	3	5.0	63	*Symphurus plagiusa*	1	4.5	90
					Natantia	3	5.0	40	*Chloroscombrus chrysurus*	1	4.5	90
					Cephalopoda	2	3.3	25	*Palaemonetes* sp.	1	4.5	90
					Glycinde solitaria	1	1.7	90	Decapoda	1	4.5	90
					Spartina alterniflora	1	1.7	90	Gastropoda	1	4.5	90
					Animal tissue	1	1.7	90	Nemotoda	1	4.5	5
Offshore	NONE[1/]	-	-	-	NONE	-	-	-	NONE	-	-	-
Totals	Pisces	109	36.5	81	Pisces	157	53.0	78	Pisces	36	31.6	51
	Brevoortia tyrannus	40	13.4	88	*Brevoortia tyrannus*	89	30.1	86	*Brevoortia tyrannus*	23	20.2	90
	Palaemonetes sp.	37	12.4	78	*Palaemonetes* sp.	22	7.4	56	*Penaeus setiferus*	13	11.4	69
	Decapoda	36	12.0	81	Crustacea	22	7.4	53	Crustacea	12	10.5	52
	Crustacea	31	10.4	68	Decapoda	9	3.0	50	*Stellifer lanceolatus*	9	7.9	87
	Alpheus heterochelis	18	6.0	67	*Menidia menidia*	8	2.7	79	*Fundulus heteroclitus*	8	7.0	83
	Penaeus setiferus	13	4.3	88	*Spartina alterniflora*	7	2.4	70	Penaeidae	8	7.0	55
	Mysidae	9	3.0	67	*Anchoa mitchelli*	6	2.0	53	*Mugil cephalus*	7	6.1	86
	Unidentified material	8	2.7	70	Cephalopoda	5	1.7	46	*Palaemonetes* sp.	4	3.5	60
	Stellifer lanceolatus	7	2.3	81	Isopoda	5	1.7	30	Isopoda	4	3.5	8

[1/] None denotes no specimens were collected with food in stomachs.

Table 48. (continued)

Sector	Fall: Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Combined Totals: Food Item	No. Stomachs	Percent Occurrence	Average % Bolus
Creeks	Pisces	36	35.0	78	Pisces	191	39.0	77
	Penaeus setiferus	21	20.4	84	*Brevoortia tyrannus*	123	25.1	87
	Brevoortia tyrannus	20	19.4	88	Crustacea	44	9.0	59
	Penaeidae	14	13.6	68	*Penaeus setiferus*	43	8.8	79
	Crustacea	7	6.8	71	Decapoda	32	6.5	73
	Mugil cephalus	5	4.9	88	Penaeidae	29	5.9	62
	Fundulus heteroclitus	3	2.9	80	*Palaemonetes* sp.	25	5.1	62
	Alpheus sp.	3	2.9	37	*Alpheus heterochelis*	18	3.7	57
	Palaemonetes sp.	3	2.9	30	*Mugil cephalus*	14	2.9	87
					Fundulus heteroclitus	12	2.4	83
Sounds	Pisces	24	44.4	75	Pisces	120	41.1	73
	Penaeus setiferus	11	20.4	85	*Brevoortia tyrannus*	39	13.4	88
	Crustacea	7	13.0	53	*Palaemonetes* sp.	35	12.0	75
	Trachypeneus constrictus	5	9.3	78	Crustacea	32	11.0	64
	Mugil cephalus	3	5.6	90	*Penaeus setiferus*	19	6.5	83
	Brevoortia tyrannus	3	5.6	80	Decapoda	15	5.1	83
	Penaeidae	3	5.6	63	Mysidae	9	3.1	67
	Lolliguncula brevis	3	5.6	53	*Alpheus heterochelis*	8	2.7	79
	Organic materials	2	3.7	10	*Menidia menidia*	8	2.7	79
	Alpheus sp.	1	1.9	90	*Lolliguncula brevis*	7	2.4	57
Beaches	Pisces	3	37.5	67	Pisces	54	58.7	77
	Penaeus setiferus	1	12.5	90	*Brevoortia tyrannus*	14	15.2	88
	Menidia menidia	1	12.5	90	*Stellifer lanceolatus*	12	13.0	81
	Stellifer lanceolatus	1	12.5	90	*Palaemonetes* sp.	6	6.5	48
	Penaeus aztecus	1	12.5	90	*Anchoa mitchilli*	5	5.4	74
	Lolliguncula brevis	1	12.5	80	Crustacea	4	4.3	40
	Brevoortia tyrannus	1	12.5	60	Decapoda	2	2.2	75
	Crustacea	1	12.5	40	Cephalopoda	2	2.2	25
					Symphurus plagiusa	1	1.1	90
					Penaeus setiferus	1	1.1	90
Offshore	NONE [1/]	-	-	-	NONE	-	-	-
Totals	Pisces	68	38.2	76	Pisces	365	41.8	76
	Penaeus setiferus	33	20.0	85	*Brevoortia tyrannus*	176	20.1	87
	Brevoortia tyrannus	24	14.5	86	Crustacea	80	9.2	60
	Penaeidae	17	10.3	67	*Palaemonetes* sp.	66	7.6	68
	Crustacea	15	9.1	61	*Penaeus setiferus*	63	7.2	80
	Mugil cephalus	8	4.8	89	Decapoda	49	5.6	76
	Trachypeneus constrictus	8	4.8	83	Penaeidae	33	3.8	63
	Lolliguncula brevis	6	3.6	48	*Alpheus* sp.	26	3.0	64
	Alpheus sp.	4	2.4	50	*Mugil cephalus*	20	2.3	88
	Stellifer lanceolatus	3	1.8	90	*Stellifer lanceolatus*	20	2.3	85

1/ None denotes no specimens were collected with food in stomachs.

opposed to a matter of days to digest fish. One would, therefore, expect to find fish and fish parts such as vertebrae and scales much more frequently in the stomach contents of seatrout even if crustaceans are the preferred food item.

The number and percent of stomachs containing food versus empty stomachs by season and sector are presented in Table 49. During spring and summer approximately 72% of the stomachs examined contained food. The percentage dropped sharply to 65.2% in fall and was lowest during winter at 55.9%. The beaches apparently had less available food supply as 43.2% of all stomachs from this sector were empty. Food availability on the beaches was lowest during winter as 81.8% of the stomaches were empty. However, since trout are less abundant on the beaches during winter, these results are from a limited sample. Low availability of food along the beaches in winter probably accounts for a major influence in seasonal movement of seatrout to the creeks and rivers in search of food as well as for refuge from the cold. However, extremely cold water temperatures often congregate trout in deeper water in the creeks and rivers as evidenced in trawl catches and recreational creels.

A comparison of the number of stomachs containing food versus empty stomachs by water temperature appears in Table 50. It appears that food was either less available or feeding activity slowed down when water temperature dropped below 15^{o}C as approximately 45% of the stomachs examined were empty. When temperatures exceeded 16^{o}C no more than 32% of the stomachs examined were empty at any temperature range.

The number and percent of stomachs containing food versus empty stomachs according to moon phase are presented in Table 51. The periods of highest feeding activity apparently occurred on intermediate days between major moon phases. During these "split phases", 73.8% of the stomachs contained food. There was an 11.5% higher occurrence of stomachs containing food during split phases than for the overall average of 64.3%. Feeding activity was also high during the week of last quarter from three days prior to and three days after last quarter. Feeding activity was the lowest during new moon and the three day period imme-

Table 49. Number and percent of spotted seatrout, *Cynscion nebulosus*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	191	56.2	149	43.8	340	100.0	106	57.6	78	42.4	184	100.0	2	18.2	9	81.8	11	100.0
Spring	136	77.3	40	22.7	176	100.0	100	74.1	35	25.9	135	100.0	60	58.3	43	41.7	103	100.0
Summer	60	81.1	14	18.9	74	100.0	32	66.7	16	33.3	48	100.0	22	62.9	13	37.1	35	100.0
Fall	103	69.6	45	30.4	148	100.0	54	58.7	38	41.3	92	100.0	8	61.5	5	38.5	13	100.0
Total	490	66.4	248	33.6	738	100.0	292	63.6	167	36.4	459	100.0	92	56.8	70	43.2	162	100.0

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	-	-	-	-	-	-	299	55.9	236	44.1	535	100.0
Spring	-	-	-	-	-	-	296	71.5	118	28.5	414	100.0
Summer	-	-	-	-	-	-	114	72.6	52	33.1	157	100.0
Fall	-	-	-	-	-	-	165	65.2	88	34.8	253	100.0
Total	-	-	-	-	-	-	874	64.3	485	35.7	1359	100.0

Table 50. Number and percent of stomachs containing food versus empty stomachs by species and surface water temperature for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Species	6-10 No.	6-10 (%)	11-15 No.	11-15 (%)	16-20 No.	16-20 (%)	21-25 No.	21-25 (%)	26-30 No.	26-30 (%)	31-35 No.	31-35 (%)	Combined No.	Combined (%)
	Surface Water Temperature (°C)													
Spotted seatrout														
Food	173	56.2	126	53.6	166	70.0	206	72.3	189	68.0	14	87.5	874	64.3
Empty	135	43.8	109	46.4	71	30.0	79	27.7	89	32.0	2	12.5	485	35.7
Total	308	100%	235	100%	237	100%	285	100%	278	100%	16	100%	1359	100%
Weakfish														
Food	25	59.5	40	58.0	42	64.6	40	93.0	56	88.9	37	84.0	240	73.6
Empty	17	40.5	29	42.0	23	35.4	3	7.0	7	11.1	7	16.0	86	26.4
Total	42	100%	69	100%	65	100%	43	100%	63	100%	44	100%	326	100%
Red drum														
Food	11	68.8	1	100.0	0	0.0	13	92.9	44	74.6	3	100.0	72	76.6
Empty	5	31.2	0	0.0	1	100.0	1	7.1	15	25.4	0	0.0	22	23.4
Total	16	100%	1	100%	1	100%	14	100%	59	100%	3	100%	94	100%
Southern flounder														
Food	8	38.1	9	45.0	4	66.7	8	57.1	64	54.2	20	47.6	113	51.1
Empty	13	61.9	11	55.0	2	33.3	6	42.9	54	45.8	22	52.4	108	48.9
Total	21	100%	20	100%	6	100%	14	100%	118	100%	42	100%	221	100%
Summer flounder														
Food	7	87.5	1	50.0	6	75.0	3	100.0	6	100.0	-	-	23	85.2
Empty	1	12.5	1	50.0	2	25.0	0	0.0	0	0.0	-	-	4	14.8
Total	8	100%	2	100%	8	100%	3	100%	6	100%	-	-	27	100%
Black drum														
Food	6	54.5	4	33.3	10	100.0	12	100.0	30	93.7	-	-	62	80.5
Empty	5	45.5	8	66.7	0	0.0	0	0.0	2	6.3	-	-	15	19.5
Total	11	100%	12	100%	10	100%	12	100%	32	100%	-	-	77	100%
Sheepshead														
Food	3	100.0	5	71.4	22	91.7	34	85.0	35	87.5	3	100.0	102	87.2
Empty	0	0.0	2	28.6	2	8.3	6	15.0	5	12.5	0	0.0	15	12.8
Total	3	100%	7	100%	24	100%	40	100%	40	100%	3	100%	117	100%
Atlantic croaker														
Food	4	100.0	16	88.9	9	100.0	25	83.3	133	87.5	49	90.7	236	88.4
Empty	0	0.0	2	11.1	0	0.0	5	16.7	19	12.5	5	9.3	31	11.6
Total	4	100%	18	100%	9	100%	30	100%	152	100%	54	100%	267	100%
Spot														
Food	9	100.0	45	75.0	74	98.7	45	75.0	87	90.6	22	100.0	282	87.9
Empty	0	0.0	15	25.0	1	1.3	14	25.0	9	9.4	0	0.0	39	12.1
Total	9	100%	60	100%	75	100%	59	100%	96	100%	22	100%	321	100%
Southern kingfish														
Food	2	66.7	59	90.8	47	85.5	23	79.3	47	77.0	10	76.9	188	83.2
Empty	1	33.3	6	9.2	8	14.5	6	20.7	14	23.0	3	23.1	38	16.8
Total	3	100%	65	100%	55	100%	29	100%	61	100%	13	100%	226	100%
Gulf kingfish														
Food	-	-	-	-	2	66.7	1	100.0	3	100.0	22	78.6	28	80.0
Empty	-	-	-	-	1	33.3	0	0.0	0	0.0	6	21.4	7	20.0
Total	-	-	-	-	3	100%	1	100%	3	100%	28	100%	35	100%

Table 51. Number and percent of stomachs containing food versus empty stomachs for each species by moon phase for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Moon Phases		3 Days Prior		New Moon		3 Days After		3 Days Prior		First Quarter		3 Days After		3 Days Prior		Full Moon		3 Days After		3 Days Prior		Last Quarter		3 Days After		Split Phases		Combined Total	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Spotted seatrout	Food	107	58.5	33	44.6	21	50.0	88	74.6	19	48.7	31	59.6	76	61.3	18	62.1	121	65.8	98	69.5	11	100.0	147	66.5	104	73.8	874	64.3
	Empty	76	41.5	41	55.4	21	50.0	30	25.4	20	51.3	21	40.4	48	38.7	11	37.9	63	34.2	43	30.5	-	-	74	33.5	37	26.2	485	35.7
	Total	183	100.0	74	100.0	42	100.0	118	100.0	39	100.0	52	100.0	124	100.0	29	100.0	184	100.0	141	100.0	11	100.0	221	100.0	141	100.0	1359	100.0
Weakfish	Food	37	75.5	-	-	3	75.0	30	69.8	11	91.7	30	83.3	7	77.8	12	54.5	27	54.0	45	90.0	-	-	27	77.1	11	78.6	240	73.6
	Empty	12	24.5	1	100.0	1	25.0	13	30.2	1	8.3	6	16.7	2	22.2	10	45.5	23	46.0	5	10.0	1	100.0	8	22.9	3	21.4	86	26.4
	Total	49	100.0	1	100.0	4	100.0	43	100.0	12	100.0	36	100.0	9	100.0	22	100.0	50	100.0	50	100.0	1	100.0	35	100.0	14	100.0	326	100.0
Red drum	Food	8	88.9	3	50.0	-	-	6	75.0	-	-	4	100.0	11	100.0	2	66.7	8	80.0	5	55.6	8	72.7	8	72.7	9	75.0	72	76.6
	Empty	1	11.1	3	50.0	-	-	2	25.0	-	-	-	-	-	-	1	33.3	2	20.0	4	44.4	3	27.3	3	27.3	3	25.0	22	23.4
	Total	9	100.0	6	100.0	-	-	8	100.0			4	100.0	11	100.0	3	100.0	10	100.0	9	100.0	11	100.0	11	100.0	12	100.0	94	100.0
Southern flounder	Food	33	68.8	1	33.3	5	38.5	20	52.6	-	-	9	75.0	1	20.0	1	33.3	9	47.4	3	42.9	2	66.7	22	43.1	7	46.7	113	51.1
	Empty	15	31.2	2	66.7	8	61.5	18	47.4	4	100.0	3	25.0	4	80.0	2	66.7	10	52.6	4	57.1	1	33.3	29	56.9	8	53.3	108	48.9
	Total	48	100.0	3	100.0	13	100.0	38	100.0	4	100.0	12	100.0	5	100.0	3	100.0	19	100.0	7	100.0	3	100.0	51	100.0	15	100.0	221	100.0
Summer flounder	Food	-	-	-	-	-	-	-	-	-	-	-	-	4	100.0	-	-	-	-	3	100.0	-	-	13	81.3	3	100.0	23	85.2
	Empty	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	100.0	-	-	-	-	-	-	3	18.7	-	-	4	14.8
	Total	-	-	-	-	-	-	-	-	-	-	-	-	4	100.0	2	100.0	-	-	3	100.0	-	-	16	100.0	3	100.0	27	100.0
Black drum	Food	14	93.3	3	100.0	-	-	11	100.0	-	-	6	50.0	8	88.9	-	-	4	66.7	2	100.0	1	100.0	7	70.0	6	85.7	62	80.5
	Empty	1	6.7	-	-	1	100.0	-	-	-	-	6	50.0	1	11.1	-	-	2	33.3	-	-	-	-	3	30.0	1	14.3	15	19.5
	Total	15	100.0	3	100.0	1	100.0	11	100.0	-	-	12	100.0	9	100.0	-	-	6	100.0	2	100.0	1	100.0	10	100.0	7	100.0	77	100.0
Sheepshead	Food	23	79.3	3	75.0	2	100.0	4	80.0	1	50.0	4	100.0	10	76.9	5	71.4	13	100.0	24	100.0	-	-	7	100.0	5	71.4	101	86.3
	Empty	6	20.7	1	25.0	-	-	1	20.0	1	50.0	-	-	3	23.1	2	28.6	-	-	-	-	-	-	-	-	2	28.6	16	13.7
	Total	29	100.0	4	100.0	2	100.0	5	100.0	2	100.0	4	100.0	13	100.0	7	100.0	13	100.0	24	100.0	-	-	7	100.0	7	100.0	117	100.0
Atlantic croaker	Food	10	76.9	4	80.0	10	100.0	49	90.7	31	100.0	33	86.8	3	60.0	3	100.0	17	89.5	31	88.6	3	100.0	22	75.9	20	90.0	236	88.4
	Empty	3	23.1	1	20.0	-	-	5	9.3	-	-	5	13.2	2	40.0	-	-	2	10.5	4	11.4	-	-	7	24.1	2	9.1	31	11.6
	Total	13	100.0	5	100.0	10	100.0	54	100.0	31	100.0	38	100.0	5	100.0	3	100.0	19	100.0	35	100.0	3	100.0	29	100.0	22	100.0	267	100.0
Spot	Food	10	38.5	-	-	15	78.9	64	100.0	2	66.7	5	100.0	20	100.0	23	100.0	21	77.8	10	100.0	2	100.0	52	96.3	58	90.6	282	87.9
	Empty	16	61.5	4	100.0	4	21.1	-	-	1	33.3	-	-	-	-	-	-	6	22.2	-	-	-	-	2	3.7	6	9.4	39	12.1
	Total	26	100.0	4	100.0	19	100.0	64	100.0	3	100.0	5	100.0	20	100.0	23	100.0	27	100.0	10	100.0	2	100.0	54	100.0	64	100.0	321	100.0
Southern kingfish	Food	21	91.3	-	-	9	75.0	16	84.2	8	80.0	19	76.0	10	83.3	2	66.7	33	86.8	34	91.9	1	100.0	24	80.0	11	68.8	188	83.2
	Empty	2	8.7	-	-	3	25.0	3	15.8	2	20.0	6	24.0	2	16.7	1	33.3	5	13.2	3	8.1	-	-	6	20.0	5	31.3	38	16.8
	Total	23	100.0	-	-	12	100.0	19	100.0	10	100.0	25	100.0	12	100.0	3	100.0	38	100.0	37	100.0	1	100.0	30	100.0	16	-	226	100.0
Gulf kingfish	Food	-	-	-	-	1	100.0	-	-	1	100.0	1	100.0	-	-	-	-	-	-	-	-	-	-	25	78.1	-	-	28	80.0
	Empty	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	21.9	-	-	7	20.0
	Total	-	-	-	-	1	100.0	-	-	1	100.0	1	100.0	-	-	-	-	-	-	-	-	-	-	32	100.0	-	-	35	100.0
Combined Species	Food	263	67.6	47	47.0	66	63.5	288	80.0	73	71.6	143	75.3	150	70.8	66	69.5	253	69.1	257	80.1	28	84.8	356	71.5	237	78.0	2227	72.3
	Empty	132	33.4	53	53.0	38	36.5	72	20.0	29	28.4	47	24.7	62	29.2	29	30.5	113	30.9	64	19.9	5	15.2	142	28.5	67	22.0	853	27.7
	Total	395	100.0	100	100.0	104	100.0	360	100.0	102	100.0	190	100.0	212	100.0	95	100.0	366	100.0	321	100.0	33	100.0	498	100.0	304	100.0	3080	100.0

diately thereafter. During new moon the high turbidity created by increased tidal amplitude and current flow, coupled with a vastly increased refuge area created by inundated saltmarshes, probably resulted in making prey more difficult to detect and capture.

Our findings did not indicate any trends in feeding activity as related by barometric pressure.

The 10 most commonly occurring organisms, identified to species level of classification, collected during the five minute trawl samples for all seasons and sectors combined included *Anchoa mitchilli*, *Micropogonias undulatus*, *Penaeus setiferus*, *Lollinguncula brevis*, *Trachypeneus constrictus*, *Acetes americanus*, *Callinectes sapidus*, *Symphurua plagiusa*, *Cynoscion regalis*, and *Stellifer lanceolatus*. Although individuals belonging to the orders Isopoda and Mysidae were abundant, limited effort was placed on the identification of these members due to the numerous species collected and difficulty associated with identification. However, other groups such as members of the genus, *Palemonetes* were collectively identified and determined to be the fourth most commonly occurring trawl organism. Table 52 lists the trawl collected organisms by season, and Table 53 lists the organisms by sector.

Of the three most commonly encountered items identified in seatrout stomachs, *Brevoortia tyrannus* was the most abundant food item but only the 15th most abundant fish species collected in trawls (Table 54). Such occurrences of *B. tyrannus* indicate an active feeding preference for this species as opposed to random feeding. *Palaemonetes* sp. and *Penaeus setiferus* were the second and third most commonly occurring food items in seatrout stomachs and also the second and third most common crustaceans collected in trawl samples. Such occurrences of these crustaceans indicate random feeding behavior. However, it should be noted that the trawl is a bottom sampling gear which may bias data by collecting primarily bottom oriented organisms as opposed to upper column or surface water organisms. Furthermore, many fish species may be capable of avoiding capture with trawls. Also, many spotted seatrout were collected adjacent to oyster reefs where trawl sampling is very difficult. Thus, conclusions drawn from comparisons of stomach contents

Table 52. Seasonal occurrence of organisms collected with trawl from the coastal waters of Glynn County, Georgia from January 1979 through June 1980.

Organism	Number Collected Winter	Spring	Summer	Fall	Total
PISCES					
Anchoa hepsetus		1	10		11
Anchoa mitchilli	75	102	50	39	266
Ancylopsetta quadrocellata	7	5			12
Anguilla rostrata	12	1		1	14
Arius felis		7	6	6	19
Astroscopus y-graecum	3	3			6
Bagre marinus	1	4	5		10
Bairdiella chrysoura	9	9	9	6	33
Brevoortia tyrannus	6	11		1	18
Caranx hippos				1	1
Centropristis philadelphica			2		2
Chaetodipterus faber		4	8	1	13
Chilomycterus schoepfi		3			3
Chloroscombrus chrysurus		1	6	4	11
Citharichthys spilopterus		2			2
Cynoscion nothus		2	5	2	9
Cynoscion regalis		31	36	11	78
Elops saurus	1	11			12
Etropus crossotus	3	3	14	6	26
Eucinostomus gula				1	1
Fundulus heteroclitus		2			2
Gobiosoma bosci	1				1
Gobioides broussonneti	2	7	3		12
Hypsoblennius hentzi	1				1
Ictalurus catus	1		1		2
Lagocephalus laevigatus		12	4	3	19
Lagodon rhomboides		1			1

Organism	Number Collected Winter	Spring	Summer	Fall	Total
Larimus fasciatus		2		5	7
Leiostomus xanthurus	22	28	6		56
Menidia menidia	15	1			16
Menticirrhus americanus	2	14	20	5	41
Menticirrhus littoralis		1			1
Micropogonias undulatus	66	74	18	30	188
Monacanthus hispidus			5		5
Mugil cephalus	1			2	3
Ophichtus ophis	1	4	3		8
Ophidion marginatum	3	15	1	2	21
Opsanus tau	1	1		1	3
Paralichthys dentatus	1	3			4
Paralichthys lethostigma				1	1
Peprilus alepidotus			2	1	3
Pomatomus saltatrix	1	3			4
Prionotus evolans				4	4
Prionotus sp.	7	27	3	5	42
Sciaenops ocellatus	1				1
Scophthalmus aquosus	1	1	1		3
Selene vomer			7	2	9
Sphyraena guachancho			1		1
Stellifer lanceolatus	19	20	14	11	64
Symphurus plagiusa	20	33	20	17	90
Syngnathidae	6	7	2	2	17
Synodus foetens			1		1
Trachinotus carolinus		2			2
Trinectes maculatus		14	8	1	23
Urophycis regia	4				4

Table 52. (continued)

Organism	Number Collected Winter	Spring	Summer	Fall	Total
ARTHROPODA					
Acetes americanus	20	37	30	24	111
Alpheus heterochelis	8	8	2	3	21
Amphipoda	2				2
Anthuridae	7	2			9
Arenaeus cribrarius				1	1
Callinectes sapidus	27	35	19	16	97
Cancer irroratus	2		2		4
Cerapus tubularius		1			1
Chthamalus fragilis	1				1
Copepoda	13	4	2	2	21
Crangon septemspinosa		1			1
Gammarus mucronatus	4				4
Hepatus epheliticus	35	19	1	4	59
Hexapanopeus angustifrons		1			1
Hippolysmata wurdemanni	4	6			10
Idotea sp.	1				1
Isopoda	50	81	11	16	158
Libinia emarginata	2	2	2	1	7
Menippe mercenaria	1	2	2	1	6
Mysidae	70	43	4	11	128
Ogyrides alphaerostris	1				1
Ovalipes ocellatus	2	1			3
Pagurus longicarpus	10	20	7	5	42
Palaemonetes sp.	68	51	23	13	155
Panopeus herbstii	7	9	4	4	24
Penaeus aztecus		14	11	1	26
Penaeus duorarum	3	12	4	4	23
Penaeus setiferus	35	36	36	27	134
Portunus gibbesii				1	1
Pycnogonida	3				3
Sesarma reticulatum		1			1
Sicyonia sp.	2				2
Squilla empusa	1	12	8	1	22
Trachypeneus constrictus	9	58	29	22	118
Uca pugilator	1	1			2
MEROSTOMATA					
Limulus polyphemus	1				1
MOLLUSCA					
Anachis avara			1		1
Busycon canaliculatum			2		2
Crassostrea virginica	6	2			8
Eupleura caudata			1		1
Mercenaria mercenaria	1	4	5		10
Modiolus demissus	2				2
Nassarius obsoletus	1				1
Nassarius vibex	26	21	7	5	59
Nudibranchia	3	2			5
Terebra dislocata	3		1		4
Simmina sp.		1			1
Triphora nigrocincta			1		1
Urosalpinx cinerea		1			1
CEPHALOPODA					
Lolliguncula brevis	12	56	37	24	129
COELENTERATA					
Anthozoa		1			1

Table 52. (continued)

Organism	Number Collected Winter	Spring	Summer	Fall	Total
COELENTERATA (cont'd)					
Coelenterata	5	19	17	1	42
Hydromedusae	21	14		4	39
Leptogorgia virgulata	2				2
Nausithoe punctata	14	12	5	1	32
Pennaria tiarella	1				1
Renilla reniformis		1	2		3
CTENOPHORA					
Ctenophora sp.	13	18	2	8	41
ANNELIDA					
Amphareta acutifrons	2				2
Cerebratulus lacteus	1	1			2
Diopatra cuprea	1				1
Glyceridae	4	2			6
Nereis sp.	1				1
Hirudenia	6	3			9
Nicolea simplex	9	2	5	2	18
Terebellidae	1	1			2
CHAETOGNATA					
Sagitta elegans	2				2
ECHINODERMATA					
Echinarachnius parma	1	2			3
Ophioderma brevispinia				1	1
Schlerodactyla briareus	2	5	1		8
PLANT MATERIAL					
Spartina alterniflora	28	16	4	4	52
Ulva lactuca	7	5		1	13
PORIFERA					
Haliclona oculata	4	4	3	3	14
Porifera	1				1
UROCHORDATA					
Molgula sp.	5	3	3	3	14
Perophora viridis	3	4			7
BRYOZOA					
Anguinella palmata	10	6		1	17
REPTILIA					
Malaclemys terrapin terrapin	1				1

Table 53. Occurrence of organisms collected by trawling by sector in the coastal waters of Glynn County, Georgia from January 1979 through June 1980.

Organism	Number Collected			
	Creek	Sound	Beach	Total
PISCES				
Anchoa hepsetus	4	2	5	11
Anchoa mitchilli	98	91	77	266
Ancylopsetta quadrocellata	6	3	3	12
Anguilla rostrata	3	7	4	14
Arius felis	3	5	11	19
Astroscopus y-graecum		2	4	6
Bagre marinus	2		8	10
Bairdiella chrysoura	13	15	5	33
Brevoortia tyrannus	1	8	9	18
Caranx hippos	1			1
Centropristis philadelphica	1	1		2
Chaetodipterus faber	3	7	3	13
Chilomycterus schoepfi	1	1	1	3
Chloroscombrus chrysurus	2	6	3	11
Citharichthys spilopterus	1	1		2
Cynoscion nothus	4		5	9
Cynoscion regalis	34	23	21	78
Elops saurus	3	4	5	12
Etropus crossotus	13	10	3	26
Eucinostomus gula	1			1
Fundulus heteroclitus			2	2
Gobioides broussoneti	8	3	1	12
Gobiosoma bosci	1			1
Hypsoblennius hentzi	1			1
Ictalurus catus	1		1	2
Lagocephalus laevigatus	7	4	8	19
Lagodon rhomboides		1		1
Larimus fasciatus	1		6	7
Leiostomus xanthurus	27	16	13	56
Menidia menidia	8	2	6	16
Menticirrhus americanus	10	15	16	41
Menticirrhus littoralis			1	1
Micropogonias undulatus	70	58	60	188
Monacanthus hispidus	1	3	1	5
Mugil cephalus	2	1		3
Ophichthus ophis	3	2	3	8
Ophidion marginatum	2		19	21
Opsanus tau	1	2		3
Paralichthys dentatus	3	1		4
Paralichthys lethostigma			1	1
Peprilus alepidotus	1	2		3
Pomatomus saltatrix	1	2	1	4
Prionotus evolans	1		3	4
Prionotus sp.	10	16	16	42
Sciaenops ocellatus	1			1
Scophthalmus aquosus	1	2		3
Selene vomer	4	3	2	9
Sphyraena guachancho			1	1
Stellifer lanceolatus	13	19	32	64
Symphurus plagiusa	36	31	23	90
Syngnathidae	4	6	7	17
Synodus foetens		1		1
Trachinotus carolinus			2	2
Trinectes maculatus	4	4	15	23
Urophycis regia	1	2	1	4

Table 53. (continued)

Organism	Creek	Sound	Beach	Total
	Number Collected			
ARTHROPODA				
Acetes americanus	23	46	42	111
Alpheus heterochelis	11	7	3	21
Amphipoda			2	2
Anthuridae	6	2	1	9
Arenaeus cribrarius	1			1
Callinectes sapidus	38	32	27	97
Cancer irroratus	1	2	1	4
Cerapus tubularius		1		1
Chthamalus fragilis	1			1
Copepoda	8	7	6	21
Crangon septemspinosa	1			1
Gammarus mucronatus	1	2	1	4
Hepatus epheliticus	17	16	26	59
Hexapanopeus angustifrons		1		1
Hippolysmata wurdemanni	1	5	4	10
Idotea sp.		1		1
Isopoda	45	57	56	158
Libinia emarginata		5	2	7
Menippe mercenaria	1	5		6
Mysidae	48	50	30	128
Ogyrides alphaerostris		1		1
Ovalipes ocellatus			3	3
Palaemontes sp.	75	56	22	155
Panopeus herbstii	10	10	4	24
Pargurus longicarpus	4	13	25	42
Penaeus aztecus	15	11		26
Penaeus duorarum	11	6	6	23
Penaeus setiferus	54	48	32	134
Portunus gibbesii			1	1
Pycnogonida		2	1	3
Sesarma reticulatum			1	1
Sicyonia sp.		1	1	2
Squilla empusa	6	6	10	22
Trachypeneus constrictus	34	33	51	118
Uca pugilator	2			2
MEROSTOMATA				
Limulus polyohemus			1	1
MOLLUSCA				
Anachis avara			1	1
Busycon canaliculatum			2	2
Crassotrea virginica	5	2	1	8
Eupleura caudata			1	1
Mercenaria mercenaria	6	1	3	10
Modiolus demissus	2			2
Nassarius obsoletus	1			1
Nassarius vibex	35	14	10	59
Nudibranchia	2	2	1	5
Terebra dislocata			4	4
Simmina sp.		1		1
Triphora nigrocincta			1	1
Urosalpinx cinerea			1	1
CEPHALOPODA				
Lolliguncula brevis	38	40	51	129
COELENTERATA				
Anthozoa	1			1

Table 53. (continued)

Organism	Number Collected Creek	Sound	Beach	Total
Hydromedusae	11	13	18	42
Leptogorgia virgulata		2		2
Hauwithe punctata	6	13	13	32
Pennaria tiarella			1	1
Renilla reniformis		1	2	3
CTENOPHORA				
Ctenophora sp.	14	16	11	41
ANNELIDA				
Amphareta arctifrons	1		1	2
Cerebratulus lacteus			2	2
Diopatra cuprea	1			1
Glyceridae	4	1	1	6
Nereis sp.	1			1
Hirudenia	3	2	4	9
Nicolea simplex	7	7	4	18
Terebellidae		1	1	2
CHAETOGNATHA				
Sagitta elegans	2		1	3
ECHINODERMATA				
Echinarachnius parma			3	3
Ophioderma brevispina			1	1
Schlerodactyla briareus		1	7	8
PLANT MATERIAL				
Spartina alterniflora	28	12	12	52
Ulva lactuca	6	3	4	13
PORIFERA				
Haliclona oculata	2	7	5	14
Porifera			1	1
UROCHORDATA				
Molgula sp.	8	6		14
Perophora viridis	2		5	7
BRYOZOA				
Anguinella palmata	4	8	5	17
REPTILIA				
Malaclemys terrapin terrapin	3			3

Table 54. The 15 most commonly occurring organisms belonging to the classes Pisces and Crustacea collected in 216 samples made with a three-meter trawl.

Pisces		Crustacea	
Organism	Number Collected	Organism	Number Collected
Anchoa mitchilli	266	Isopoda	158
Micropogonias undulatus	188	*Palaemonetes sp.*	155
Symphurus plagiusa	90	*Penaeus setiferus*	134
Cynocion regalis	78	Mysidae	128
Stellifer lanceolatus	64	*Trachypeneus constrictus*	118
Leiostomus xanthurus	56	*Acetes americanus*	111
Prionotus sp.	42	*Callinectes sapidus*	87
Menticirrhus americanus	41	*Hepatus opheliticus*	59
Bairdiella chrysoura	33	*Pagurus longicarpus*	42
Etropus crossotus	26	*Penaeus aztecus*	26
Trinectes maculatus	23	*Panopeus herbstii*	24
Ophidion marginatum	21	*Penaeus duorarum*	23
Arius felis	19	*Squilla empusa*	22
Lagocephalus laevigatus	19	*Alpheus heterochelis*	21
Brevoortia tyrannus	18	Copepoda	21

with available food items determined from trawl samples were limited.

WEAKFISH

Weakfish *(Cynoscion regalis)* range from west-central to south Florida in the Gulf of Mexico and along the Altantic coast from south Florida to Nova Scotia (Fischer, 1978).

Weakfish prefer habitats very similar to that of spotted seatrout. However, they are generally found in deeper waters within the estuarine systems. As opposed to spotted seatrout, most larger weakfish move offshore during the colder months, but juveniles may remain in Georgia estuaries year-round.

Movement and Migration

From February 7, 1979 through June 28, 1982, 2,958 weakfish were tagged and released. Length frequencies of tagged weakfish in 50 mm length groups are included in Table 55. Lengths (TL) of weakfish tagged with Howitt tags ranged from 118 to 475 mm, and with Floy tags from 103-440 mm. Length frequencies of weakfish tagged with each tag type are shown in Table 56. Table 57 lists the length frequencies of weakfish collected for tagging in 20 mm groups by gear type.

Tagged weakfish were returned from October 31, 1979 through March 15, 1982. Of the 2,958 weakfish tagged, 48 (1.6%) were recaptured and tags returned. Recovery rates, when separated into 50 mm length groups, ranged as high as 8.9%. Information on the number of fish released and recaptured, time at large, and distance traveled are shown in Table 55. The time at large for weakfish ranged from 1 to 367 days, averaging 62 days. Distance traveled ranged as far as 167 km with an average of 8.3 km.

The overall recovery rate was 2.0% for weakfish tagged with Howitt tags and only 0.2% for fish tagged with Floy tags (Table 56). However, approximately 77% of the weakfish tagged with Floy tags were smaller than the minimum creel size fish captured by recreational fishermen (Table 12). Recovery rates of tagged weakfish, when separated into 50 mm length groups, ranged as high as 9.5% with Howitt tags and 0.5%

Table 55. Number tagged, number and percent recaptured, days at large and distance traveled for weakfish, *Cynoscion regalis*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large Avg.	Days At Large Max.	Distance Traveled (km) 1/ Avg.	Distance Traveled (km) 1/ Max.
101 - 150	231	1	0.4	1	1	0.0	0
151 - 200	1,053	0	0.0				
201 - 250	750	3	0.4	153	367	15.4	39
251 - 300	209	3	1.4	70	79	31.5	80
301 - 350	364	12	3.3	103	299	3.2	24
351 - 400	298	25	8.4	38	335	8.7	167
401 - 450	45	4	8.9	24	43	0.0	0
451 - 500	8	0	0.0				
Total	2,958	48	1.6	62	367	8.3	167

1/ Distance measured in kilometers from point of release to point of recapture.

Table 56. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for weakfish, *Cynoscion regalis*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
125	25			206	1	0.5	231	1	0.4
175	787			266			1,053		
225	664	3	0.5	86			750	3	0.4
275	185	3	1.6	24			209	3	1.4
325	347	12	3.5	17			364	12	3.3
375	286	25	8.7	12			298	25	8.4
425	42	4	9.5	3			45	4	8.9
475	8						8		
Total	2,344	47	2.0	614	1	0.2	2,958	48	1.6

Table 57. **Number of weakfish, *Cynoscion regalis*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.**

Length Group (mm)	Gill Net (in)[1/] 2	2-7/8	3-1/2	4-5/8	Trammel Net	Seine	Trawl	Totals
110	-	-	-	-	-	-	10	10
130	-	-	-	-	-	-	122	122
150	1	1	-	-	-	-	241	243
170	11	-	-	-	-	-	359	370
190	2	-	-	-	-	-	537	539
210	-	-	-	-	-	-	449	449
230	1	1	-	-	-	-	229	231
250	1	2	-	-	1	-	122	126
270	-	2	-	-	2	-	84	88
290	3	14	-	-	-	-	48	65
310	5	54	-	-	5	-	27	91
330	3	141	-	1	8	-	13	166
350	2	180	-	1	17	-	5	205
370	1	118	1	2	12	1	-	135
390	-	52	-	4	7	-	2	65
410	-	24	1	4	1	-	-	30
430	-	7	-	3	2	-	-	12
450	-	4	-	-	-	-	-	4
470	-	7	-	-	-	-	-	7
Totals	30	607	2	15	55	1	2248	2958

1/ Gill net sizes are stretch mesh measurements.

with Floy tags. Similar contrasting tag retention qualities were observed with release-recapture of spotted seatrout (Table 8).

Recreational fishermen accounted for 17 (35.4%) of the 48 recoveries. Seven (14.6%) returns were from commercial shrimp fishermen, and 24 (50.0%) were obtained through study activities (Table 11). Of the 17 recreational recaptures, only 11 (65%) included sufficient information to determine lengths of creel size fish. Lengths of recreational recaptures ranged from 205 to 392 mm with an average size of 326 mm (Table 12). Length frequencies of recaptured weakfish indicated that most creel size fish (54.5%) ranged from 350 to 500 mm (Table 13). Approximately 43% of all weakfish tagged were smaller than the minimum length of any creel size fish recaptured by recreational fishermen.

Sufficient recapture information was obtained to determine the estuarine sector location and season of capture for all recaptured weakfish. The sounds produced 75.0% of the recoveries (Table 14). However, the higher return rate from this area was apparently the result of the higher number of weakfish (90.4%) released in the sounds. Creek, beach, and offshore sectors produced 6 (12.5%), 2 (4.2%), and 4 (8.3%) recoveries, respectively. Although recovery information was limited, data indicate most recoveries (77.8%) were taken in the sounds during the fall. Weakfish do occur in the upper creeks in the fall but move to areas with higher salinities in the winter (Table 15).

All weakfish recaptured by recreational fishermen were caught by Georgia residents in Georgia waters. Most fishermen (76%) traveled less than 40 km to reach the location of fish recapture (Table 16).

The principal bait used by recreational fishermen to catch weakfish was shrimp (86%), and the number of recoveries caught with live or dead shrimp was equal (Table 17). Artificial lures and cut bait accounted for the remainder.

Approximately 67% of weakfish recoveries were caught in the immediate area of release. This percentage is greater than observed for spotted seatrout (49.2%), but the average at large time for spotted seatrout was approximately five months longer (Tables 7 and 55). Of

the 46 weakfish recoveries with sufficient information to ascertain movement, 43 (93.5%) were recaptured within 25 km of the release site (Table 58). However, recovery information was insufficient to determine seasonal movement within the estuary (Table 59). Recovery data indicate weakfish 200 to 300 mm generally exhibit greater movement than larger individuals (Table 55). Although one 362 mm weakfish traveled the greatest distance (167 km), the remaining individuals (24) in this length group (351-400 mm) averaged only 2.3 km.

Only one weakfish migrated out of Georgia waters. This individual was tagged in St. Simons Sound and recaptured 43 days later in Matanzas Inlet, Florida by a commercial shrimper, a distance of 167 km. Migration was generally to offshore waters during spawning and cold water months. Recovery data were insufficient to document if weakfish return to their original estuary. Only three weakfish traveled more than 25 km before recapture, thus limiting movement analyses. Two of the three migrated southward and were recaptured during November. The third individual migrated northward and was recaptured during April.

Although recovery information was insufficient to document extensive movements of Georgia weakfish, migration of weakfish on the Atlantic coast of the United States was previously reported by Wilk (1979). He reported that young individuals, less than four years old, migrated southward below Cape Hatteras as far as Florida in fall and winter and northward in spring and summer. Individuals over four years old migrated southward as far as North Carolina in the fall and returned to their northern estuaries in spring. Although weakfish over three years old do occur in Georgia estuaries, recovery information was insufficient to ascertain their movements. Beaumariage (1969) tagged nine weakfish and only three were recovered. No movement or growth was observed for these three specimens.

Length-Weight Relationship

Length and weight measurements were collected for 327 weakfish ranging from 92 to 564 mm and 15 to 2,319 g, respectively. The

with Floy tags. Similar contrasting tag retention qualities were observed with release-recapture of spotted seatrout (Table 8).

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All weakfish recaptured by recreational fishermen were caught by Georgia residents in Georgia waters. Most fishermen (76%) traveled less than 40 km to reach the location of fish recapture (Table 16).

The principal bait used by recreational fishermen to catch weakfish was shrimp (86%), and the number of recoveries caught with live or dead shrimp was equal (Table 17). Artificial lures and cut bait accounted for the remainder.

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Length-Weight Relationship

Length and weight measurements were collected for 327 weakfish ranging from 92 to 564 mm and 15 to 2,319 g, respectively. The

Table 58. Days at large and distance traveled for weakfish, *Cynoscion regalis*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Days At Large	Distance Traveled (km)							Total	Percent
	0	0.1-1	1-5	6-25	26-50	51-100	101-200		
1 - 50	19	1	2	5	1	-	1	29	63.0
51 - 100	6	-	-	2	-	1	-	9	19.6
101 - 150	1	-	-	-	-	-	-	1	2.2
151 - 200	4	-	-	-	-	-	-	4	8.7
201 - 300	1	-	-	1	-	-	-	2	4.3
301 - 500	-	1	-	-	-	-	-	1	2.2
Total	31	2	2	8	1	1	1	46	100.0
Percent	67.4	4.3	4.3	17.4	2.2	2.2	2.2	100.0	

NOTE: Only 46 of the 48 recaptures had sufficient information to calculate distance traveled.

Table 59. Seasonal movement of weakfish, *Cynoscion regalis*, tagged in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Season	Length Group (mm)	Caught In Area Of Release	Movement Within Estuary: Creek to Beach	Movement Within Estuary: Beach To Creek	Movement Out Of Estuary: North	Movement Out Of Estuary: South
Winter	201-250	-	-	-	-	-
	251-300	-	-	-	-	-
	301-350	1	1	-	-	1
	351-400	-	1	-	-	1
	401-450	-	-	-	-	-
	Total	1	2	-	-	2
	Percent	20.0	40.0	-	-	40.0
Spring	201-250	-	1	-	-	-
	251-300	-	-	-	1	-
	301-350	4	-	-	-	-
	351-400	-	-	-	-	-
	401-450	-	-	-	-	-
	Total	4	1	-	1	-
	Percent	66.6	16.7	-	16.7	-
Summer	201-250	-	-	-	-	-
	251-300	-	-	-	-	-
	301-350	2	-	-	-	-
	351-400	-	-	-	-	-
	401-450	-	-	-	-	-
	Total	2	-	-	-	-
	Percent	100.0	-	-	-	-
Fall	201-250	-	-	-	2	-
	251-300	-	-	1	-	-
	301-350	7	-	-	-	1
	351-400	14	-	2	1	2
	401-450	3	-	-	-	-
	Total	24	-	3	3	3
	Percent	72.7	-	9.1	9.1	9.1
Combined	Total	31	3	3	4	5
	Percent	67.4	6.5	6.5	8.7	10.9

length-weight relationship equations for males, females, and combined sexes are shown in Table 24. Figure 22 illustrates the length-weight relationships for weakfish. The length-weight relationships calculated showed isometric growth (b = 2.920). The greatest lengths recorded for male and female weakfish were 397 and 564 mm, respectively. The heaviest weakfish weighed 640 g for males and 2,319 g for females.

Wilk (1980) presented length-weight equations for weakfish collected in the New York Bight. Weights were similar to those for Georgia fish of equal length. There also appears to be little difference between male and female length-weight relationships.

Age and Growth

The scale technique for ageing weakfish has been validated as an ageing method by Welsh and Breder (1924), Massmann (1963) and Wilk (1979). Scale annuli marks were described by Massmann (1963) as: 1) cutting over of circuli which are most apparent in the lateral field; 2) crowding together of circuli in the anterior portion of the scale; and 3) the appearance of secondary radii originating at zones where circuli are crowded together.

Scale samples from 311 weakfish ranging from 77 to 564 mm were examined, and 243 (78%) were determined usable for age analyses. Otolith sections of these 243 fish were also examined to document the validity of annuli counts made from scales. Year-mark formation on weakfish scales and otoliths are similar to that observed for spotted seatrout. Considering the scale-otolith year mark difference as observed for spotted seatrout, scales and otoliths examined from the same weakfish exhibited 95.9% agreement in age.

Calculation of mean monthly growth of marginal increments validated that scale annuli are formed only once annually. A single annulus formation was detectable on most weakfish scales from late March through June with all scales bearing recent annuli by early July.

Least-squares regression analyses were performed on the relationship between fish length and scale radius. The r^2 value of 0.82

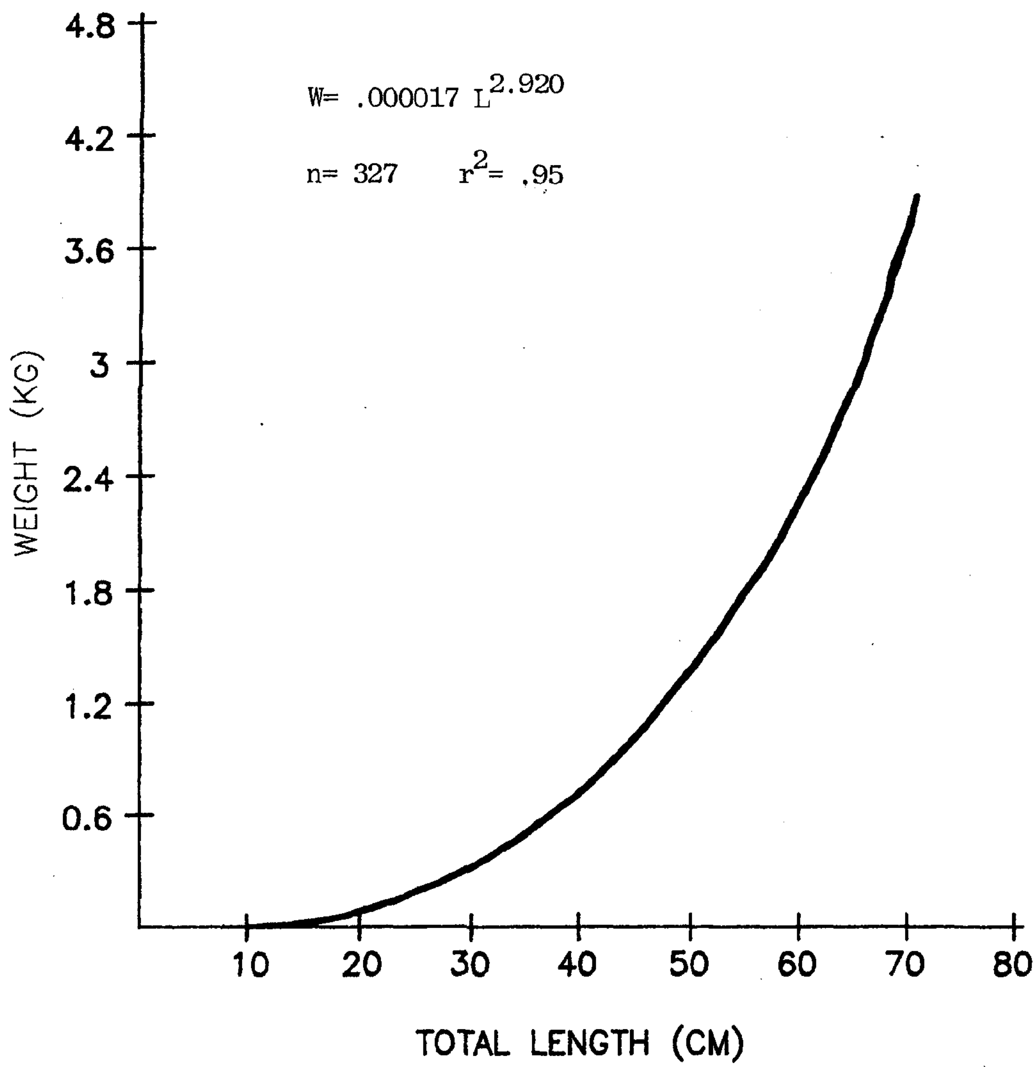

Figure 22. Length-weigth relationship of weakfish, *Cynoscion regalis*, collected in Glynn County, Georgia from January 1979 through June 1982.

(P < 0.0001) suggests the relationship was sufficiently linear to warrant direct proportion calculations to determine fish lengths at time of annulus formation. The empirical and mean back-calculated total lengths of weakfish by age are shown in Table 60. Figure 23 illustrates the length-age relationship for weakfish, and length-age equations are included in Table 27. Table 61 shows the empirical and weighted-mean back-calculated lengths for juveniles, males, females, and combined weakfish.

To document the annual growth rate of weakfish, the mean growth for all weakfish at large from 11 to 13 months were calculated. Unfortunately, recapture lengths were obtained for only two weakfish at large for approximately one year. One specimen measured 228 mm when released and had grown 64 mm, and the other originally measured 397 mm and had grown only 13 mm. Thus, sufficient recapture information was not available to document growth rates derived from back-calculations.

The oldest weakfish collected during this study were an age VII female and an age IV male. Maximum ages for combined weakfish in Georgia are similar to ages reported by Welsh and Breder (1924), Massmann (1963), and Wilk (1979). Mean back-calculated lengths for Georgia weakfish under six years of age are similar to the findings of several studies as reported by Wilk (1979). However, Georgia weakfish are generally smaller at age than fish from the more northern waters.

Maturity and Spawning

Sex differentiation through gross examination was first observed at 146 mm (age 0) for females and 165 mm (age 0) for males. The smallest female exhibiting developing ovaries (stage III or greater) was a 275 mm (age II) specimen. The smallest male exhibiting developing maturity was a 370 mm (age III) specimen. Gear selectivity may have biased the collection of males toward larger specimens.

Wilk (1973) reported that weakfish are sexually mature for the first time in their second year of life. Merriner (1976) reported

Table 60. Mean back-calculated total lengths for weakfish, *Cynoscion regalis*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back-Calculated Lengths of Successive Scale Rings: 1	2	3	4	5	6	7
0	23	77 - 217	151							
1	42	140 - 327	213	144						
2	84	205 - 386	316	172	266					
3	82	267 - 459	363	158	260	327				
4	9	345 - 438	395	166	273	333	374			
5	2	401 - 505	453	193	298	355	393	439		
6	0									
7	1	564	564	217	288	357	403	457	500	544
		Weighted Means		162	264	329	380	445	500	544
		Growth Increments		162	102	65	51	65	55	44

NOTE: Lengths measured in millimeters.

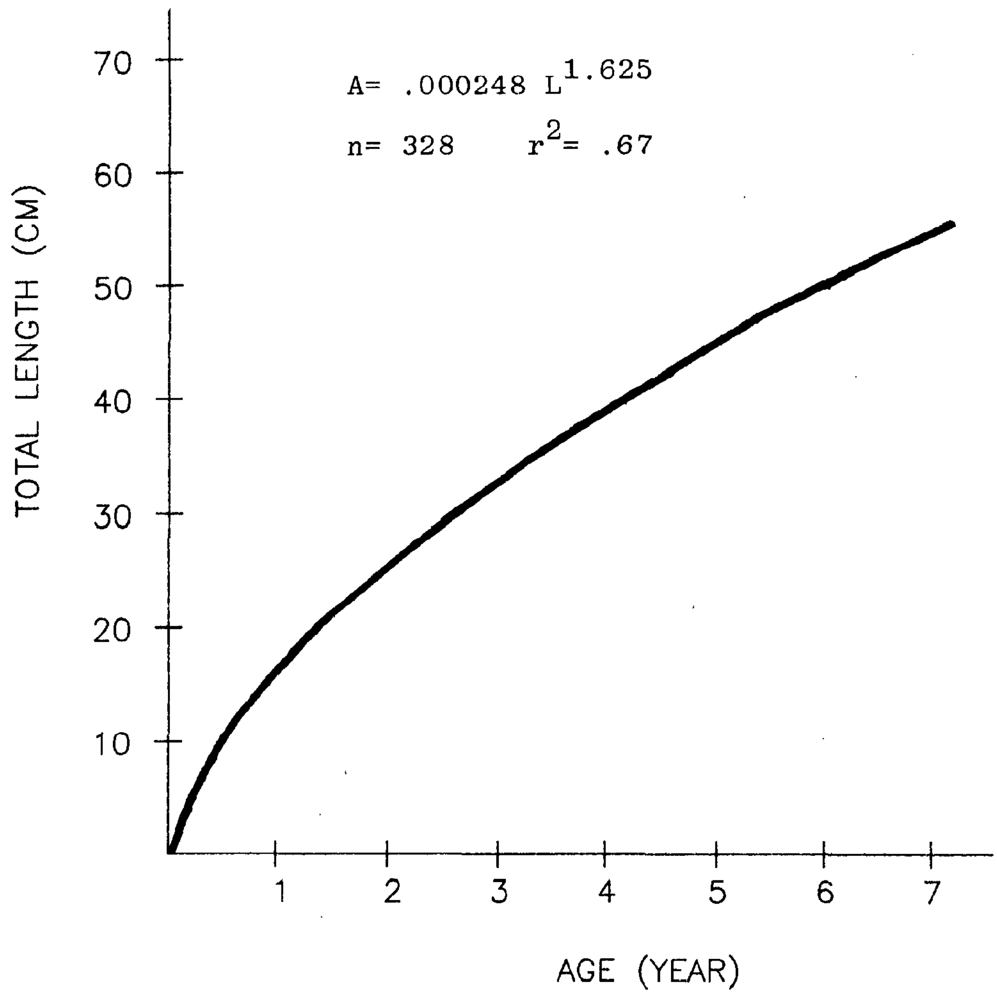

Figure 23. Length-age relationship of weakfish, *Cynoscion regalis*, collected in Glynn County, Georgia.

Table 61. Number, empirical and back-calculated total lengths and growth increments by sex and age for weakfish, *Cynoscion regalis*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Sex	Age 1	2	3	4	5	6	7
Juveniles							
Number	4	1					
Mean Length at Capture	159	259					
Back-Calculated Length	120	208					
Growth Increment	120	88					
Males							
Number	13	14	7	2			
Mean Length at Capture	195	279	333	371			
Back-Calculated Length	151	251	309	348			
Growth Increment	151	100	58	39			
Females							
Number	25	69	75	7	2	0	1
Mean Length at Capture	231	325	365	402	453		564
Back-Calculated Length	166	266	331	386	445	500	544
Growth Increment	166	100	65	55	59	55	44
Combined							
Number	42	84	82	9	2	0	1
Mean Length at Capture	213	316	363	395	453		564
Back-Calculated Length	162	264	329	380	445	500	544
Growth Increment	162	102	65	51	65	55	44

NOTE: Lengths measured in millimeters.

that both females and males become sexually mature at age I with a few maturing at age II in North Carolina waters. Wilk (1979) reported that most, if not all, weakfish are sexually mature by age II.

Georgia weakfish have a protracted spawning season extending from March through September. The stages of gonadal development for female and male weakfish are presented by month in Table 62. Only 16 female weakfish exhibiting advanced stages of ovarian development were collected and these came from the inside waters from the beaches inward. Of all females collected during March, 12.5% exhibited advanced ovarian development. Spawning activity apparently peaked in April when 29.4% of the females exhibited advanced development. The percentage dropped sharply to 13.3% in May and 10.3% in June. No advanced development was observed in July and August, but two prespawn females (stage V) were collected in September.

Very early postlarval and yolk stage weakfish were collected in ichthyoplankton samples from the beach in May (Table 63). Unfortunately, laboratory identification of plankton samples were contracted only for the initial 5-month period of January through May. No young weakfish were collected in the 3 meter trawl samples during winter, but their numbers increased sharply in spring, peaked in summer and then sharply declined again in fall (Table 52). Although young specimens were distributed throughout the estuaries, there was an increase in occurrence from the beaches to the creeks (Table 53). There was near equal occurrence of young in the sounds and on the beaches, but there was approximately a 30% higher occurrence rate in the creeks.

The reproductive stages for female and male weakfish by month and salinity appear in Table 64. No advanced stages of ovarian development were observed from salinities <15 $^{o}/oo$. Advanced ovarian development was observed at salinities above 16 $^{o}/oo$ but females in spawning condition were found only in salinities above 26 $^{o}/oo$, indicating that most weakfish spawning activity takes place in the high salinity waters near the beaches and open ocean. Georgia's sounds are relatively small and little effort would have to be exerted for prespawners to move to

Table 62. Number of weakfish, *Cynoscion regalis*, collected by month, sex and reproductive stage for the period January 1979 through June 1982.

	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
Month	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	16	1	9	0	1	0								
February	2	0	28	0	0	0								
March	2	3	19	2	7	0	2	1	2	0				
April	0	2	4	1	8	0	2	0	3	0				
May	4	1	7	0	2	0	1	0			1	0		
June	4	4	15	0	7	0			3	0				
July	9	10	6	0	1	0								
August	1	0	2	0										
September	20	5	2	0	1	0			2	0				
October	7	2	5	0	2	0								
November	16	1	6	0	1	0								
December	9	10	13	0	1	0								

Table 63. Ichthyoplankton collected by month in Glynn County, Georgia from January 1979 through May 1979.

Species	January				February				March			
	Creeks	Sounds	Beaches	Total	Creeks	Sounds	Beaches	Total	Creeks	Sounds	Beaches	Total
Leiostomus xanthurus	13-Pl[1/]	9-Pl	5-PL	27-Pl	27-Pl	-	-	27-Pl	-	-	-	-
Micropogonias undulatus	-	-	1-Pl	1-Pl	-	-	-	-	-	-	-	-
Bothidae	-	-	-	-	-	4-Pl	-	4-Pl	-	-	-	-
Gobiidae	-	-	-	-	-	-	-	-	-	-	-	-
Sciaenidae	-	-	-	-	-	-	-	-	-	-	-	-
Mugil sp.	-	-	1-Pl	1-Pl	-	-	-	-	-	-	-	-
Menidia menidia	-	3-Ad[3/]	-	3-Ad	3-Ad	-	4-Ad	7-Ad	1-Ys[2/] 3-Pl	5-Ys; 17-Pl 2-Ad	2-Pl 2-Ad	6-Ys; 22-Pl 4-Ad
Lagodon rhomboides	5-Pl	2-Pl	-	7-Pl	8-Pl	6-Pl	-	14-Pl	2-Pl	1-Pl	-	3-Pl
Anchoa mitchilli	-	1-Ad	1-Ad	2-Ad	1-Jv[4/]	3-Jv	2-Jv 1-Ad	5-Jv 1-Ad	-	-	1-Jv 1-Ad	1-Jv 1-Ad
Myrophis punctatus	1-Le[5/]	-	2-Le	3-Le	-	-	-	-	-	-	-	-
Pisces	-	-	-	-	1-Pl	-	-	1-Pl	3-Pl	1-Pl	-	4-Pl
Brevoortia sp.	-	-	-	-	-	-	19-Pl	19-Pl	9-Pl	29 Pl	2-Pl	40-Pl
Engraulidae	-	-	-	-	-	-	-	-	-	-	-	-
Clupeidae	-	-	-	-	-	-	-	-	-	-	-	-
Blenniidae	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathidae	-	-	-	-	-	-	-	-	-	-	-	-
Sphoeroides sp.	-	-	-	-	-	-	-	-	-	-	-	-
Anchoa hepsetus	-	-	-	-	-	-	-	-	-	-	-	-
Cynoscion regalis	-	-	-	-	-	-	-	-	-	-	-	-
Monocanthus hispidus	-	-	-	-	-	-	-	-	-	-	-	-
Menticirrhus sp.	-	-	-	-	-	-	-	-	-	-	-	-
Fundulus sp.	-	-	-	-	-	-	-	-	-	-	-	-
Trinectes maculatus	-	-	-	-	-	-	-	-	-	-	-	-
Prionotus sp.	-	-	-	-	-	-	-	-	-	-	-	-

1/ Pl = Postlarval 2/ Ys = Yolkstage 3/ Ad = Adult 4/ Jv = Juvenile 5/ = Leptocephalus

Table 63. (continued)

Species	April Creeks	April Sounds	April Beaches	April Total	May Creeks	May Sounds	May Beaches	May Total
Leiostomus xanthurus	-	-	-	-	-	-	-	-
Micropogonias undulatus	-	-	-	-	-	-	-	-
Bothidae	-	-	-	-	-	-	-	-
Gobiidae	4-PL [1]	4-Pl	-	8-Pl	50-Pl	1-Ys;[2] 5-Pl	6-Pl	1-Ys; 61-Pl
Sciaenidae	1-Ys; 4-PL	7-Pl	-	1-Ys; 11-Pl	-	1-Pl	-	1-Pl
Mugil sp.	-		-	-	-	2-Pl	-	2-Pl
Menidia menidia	1-Ys 35-Pl	152-Pl	1-Ys 9-Pl	2-Ys 196-Pl	1-Ys; 29-Pl 1-Jv	8-Ys; 23-Pl 1-Jv	3-Pl	9-Ys; 55-Pl 2-Jv
Lagodon rhomboides	-	-	4-Pl	4-Pl	-	1-Pl	-	1-Pl
Anchoa mitchilli	1-Ad[3]	2-Ad	-	3-Ad	174-Pl 1-Jv [4]	21-Pl 4-Ad	43-Pl 11-Ad	238-Pl; 1-Jv 15-Ad
Myrophis punctatus	-	-	-	-	-	-	-	-
Pisces	-	4-Ys	4-Ys	8-Ys	1-Pl	3-Pl	-	4-Pl
Brevoortia sp.	-	-	7-Pl	7-Pl	-	-	-	-
Engraulidae	4-Pl	20-Pl	1-Pl	25-Pl	2327-Pl	1-Ys; 54-Pl	120-Pl	1-Ys; 2501-Pl
Clupeidae	1-Pl	40-Pl	4-Pl	45-Pl	-	-	-	-
Blenniidae	4-Ys; 4-Pl	-	-	4-Ys; 4-Pl	-	-	1-Pl	1-Pl
Syngnathidae	-	-	1-Jv; 1-Ad	1-Jv; 1-Ad	-	2Pl; 2-Jv	-	2-Pl; 2-JV
Sphoeroides sp.	-	-	2-Jv	2-Jv	1-Pl	1-Jv	1-Jv	2-Jv; 1-Pl
Anchoa hepsetus	-	-	-	-	7-Pl 1-Jv	15-Pl	69-Pl	91-Pl 1-Jv
Cynoscion regalis	-	-	-	-	-	-	10-Ys 16-Pl	10-YS 16-Pl
Monocanthus hispidus	-	-	-	-	-	-	1-Jv	1-Jv
Menticirrhus sp.	-	-	-	-	-	-	1-Ad	1-Ad
Fundulus sp.	-	-	-	-	-	-	1-Ys	1-Ys
Trinectes maculatus	-	-	-	-	-	-	2-Pl	2-Pl
Prionotus sp.	-	-	-	-	-	-	1-Pl	1-Pl

[1] PL = Postlarval [2] Ys = Yolk stage [3] Ad=Adult [4] Jv = Juvenile [5] Le = Leptocephalus

Table 64. Stages of gonadal development for weakfish, *Cynoscion regalis*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

		Surface Water Salinity (0/00)																	
	Reproductive	0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		Totals	
Month	Stage	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	I	-	-	-	-	-	-	-	-	13	1	3	0	-	-	-	-	16	1
	II	-	-	-	-	-	-	-	-	5	0	4	0	-	-	-	-	9	0
	III	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I	-	-	-	-	-	-	2	0	-	-	-	-	-	-	-	-	2	0
	II	-	-	-	-	-	-	6	0	1	0	21	0	-	-	-	-	28	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I	-	-	-	-	1	0	-	-	1	0	0	3	-	-	-	-	2	3
	II	-	-	-	-	2	0	13	1	1	1	3	0	-	-	-	-	19	2
	III	-	-	-	-	-	-	6	0	1	0	-	-	-	-	-	-	7	0
	IV	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	2	1
	V	-	-	-	-	-	-	2	0	-	-	-	-	-	-	-	-	2	0
	VI-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	-	-	-	-	-	-	-	-	0	1	0	1	-	-	-	-	0	2
	II	-	-	-	-	-	-	-	-	-	-	1	1	3	0	-	-	4	1
	III	-	-	-	-	1	0	1	0	3	0	2	0	1	0	-	-	8	0
	IV	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	V	-	-	-	-	-	-	1	0	-	-	1	0	1	0	-	-	3	0
	VI	-	-	-	-	-	-	-	-	-	-	4	0	-	-	-	-	4	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	I	-	-	-	-	-	-	1	0	3	1		-	-	-	-	-	4	1
	II	-	-	-	-	-	-	3	0	1	0	3	0	-	-	-	-	7	0
	III	-	-	-	-	-	-	1	0	-	-	1	0	-	-	-	-	2	0
	IV	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VI	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	I	-	-	-	-	-	-	-	-	-	-	0	2	4	2	-	-	4	4
	II	-	-	-	-	-	-	-	-	-	-	1	0	14	0	-	-	15	0
	III	-	-	-	-	-	-	-	-	-	-	-	-	7	0	-	-	7	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	-	-	3	0	-	-	3	0
	VI-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 64. (continued)

Month	Reproductive Stage	Surface Water Salinity (0/00) 0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		Totals	
		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
July	I	-	-	-	-	-	-	-	-	-	-	0	1	9	9	-	-	9	10
	II	-	-	-	-	-	-	-	-	-	-	1	0	5	0	-	-	6	0
	III	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	I	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	II	-	-	-	-	-	-	-	-	1	0	1	0	-	-	-	-	2	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I	-	-	-	-	-	-	7	3	1	0	11	2	1	0	-	-	20	5
	II	-	-	-	-	-	-	-	-	1	0	-	-	1	0	-	-	2	0
	III	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	1	0	1	0	-	-	-	-	-	-	2	0
	VI-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I	-	-	-	-	-	-	4	2	2	0	1	0	-	-	-	-	7	2
	II	-	-	-	-	-	-	5	0	-	-	-	-	-	-	-	-	5	0
	III	-	-	-	-	-	-	2	0	-	-	-	-	-	-	-	-	2	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I	-	-	-	-	-	-	1	0	-	-	13	1	2	0	-	-	16	1
	II	-	-	-	-	-	-	-	-	-	-	5	0	1	0	-	-	6	0
	III	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I	-	-	-	-	-	-	-	-	8	10	1	0	-	-	-	-	9	10
	II	-	-	-	-	-	-	-	-	9	0	4	0	-	-	-	-	13	0
	III	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combined Totals	I	-	-	-	-	1	0	15	5	28	13	30	10	16	11	-	-	90	39
	II	-	-	-	-	2	0	27	1	19	1	44	1	24	0	-	-	116	3
	III	-	-	-	-	1	0	10	0	7	0	5	0	8	0	-	-	31	0
	IV	-	-	-	-	-	-	2	1	-	-	3	0	-	-	-	-	5	1
	V	-	-	-	-	-	-	4	0	1	0	1	0	4	0	-	-	10	0
	VI	-	-	-	-	-	-	-	-	-	-	5	0	-	-	-	-	5	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ocean waters to spawn.

The maturity stages for female and male weakfish are presented by temperature and salinity in Table 65. Gonadal development was first observed when water temperature exceeded 6°C. However, spawning activity was apparently not fully underway until water temperatures exceeded 16°C.

At salinities below 15 ‰ no ovarian development was observed, but at salinities ranging from 16 to 20 ‰ advanced ovarian development appeared in 10.4% of the females examined. Ripe females (stage VI) were not found until water temperatures exceeded 21°C and only in salinity above 26 ‰. Low numbers of advanced stages of gonadal development made it difficult to determine the precise time and location of spawning. However, most of the adult weakfish collected during this study came from St. Simons Sound near the mouth of Dubignion Creek on the north shore of Jekyll Island. This was the only sampling site to regularly produce larger weakfish in concentrated numbers. This site is less than 0.5 nautical mile from open ocean waters and is readily accessible for rapid movement seaward for spawning in the ocean waters.

The number and percent of weakfish showing signs of advanced gonadal development by lunar phase appear in Table 40. Although low numbers of advanced maturity stages were collected, the greatest occurrence was during new moon and last quarter. Of the 20 advanced stages observed, 30% occurred during new moon, 5% during first quarter, 25% during full moon, 30% during last quarter and 10% during split phases. Too few specimens were collected to draw definite conclusions.

The sex ratios for weakfish by length group appear in Table 41. The overall ratio of female to male weakfish collected during this study was 6:1. For young weakfish <200 mm the ratio was equal at 1:1 females to males. The ratio increased sharply to 9.5:1 for fish 301-350 mm and was 47:1 for fish 351-400 mm. No males over 400 mm were collected. Gear selectivity may have accounted for some bias in the collection of males. However, such an extraordinarily high ratio of females to males indicates that there was probably some natural phenomenon regulating sex segregation within the weakfish population in inside waters. It is

Table 65. Stages of gonadal development for weakfish, *Cynoscion regalis*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)	Reproductive Stage	Surface Water Temperature (°C) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	Totals F	Totals M
	I	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
	II	-	-	-	-	-	-	2	0	-	-	-	-	-	-	2	0
11-15	III	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	2	0	-	-	1	0	5	2	7	3	-	-	15	5
	II	-	-	12	0	-	-	7	1	8	0	-	-	-	-	27	1
	III	-	-	5	0	-	-	1	0	4	0	-	-	-	-	10	0
16-20	IV	-	-	0	1	-	-	2	0	-	-	-	-	-	-	2	1
	V	-	-	1	0	-	-	2	0	-	-	1	0	-	-	4	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	-	-	22	11	0	1	3	1	3	0	-	-	28	13
	II	-	-	-	-	14	1	2	0	1	0	2	0	-	-	19	1
	III	-	-	-	-	2	0	4	0	-	-	1	0	-	-	7	0
21-25	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	-	-	4	0	13	5	-	-	12	5	1	0	30	10
	II	-	-	21	0	8	0	8	0	3	1	3	0	1	0	44	1
	III	-	-	-	-	-	-	3	0	-	-	2	0	-	-	5	0
26-30	IV	-	-	-	-	-	-	2	0	-	-	-	-	-	-	2	0
	V	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	VI	-	-	-	-	-	-	-	-	5	-	-	-	-	-	5	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	2	0	-	-	9	4	5	7	16	11
	II	-	-	-	-	-	-	2	0	2	0	2	0	18	0	24	0
	III	-	-	-	-	-	-	-	-	1	0	-	-	7	0	8	0
31-35	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	1	0	-	-	3	0	4	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	2	0	27	11	16	6	8	3	31	12	6	7	90	39
	II	-	-	33	0	22	1	21	1	14	1	7	0	19	0	116	3
	III	-	-	5	0	2	0	9	0	5	0	3	0	7	0	31	0
TOTALS	IV	-	-	0	1	-	-	4	0	-	-	-	-	-	-	4	1
	V	-	-	1	0	-	-	3	0	1	0	2	0	3	0	10	0
	VI	-	-	-	-	-	-	-	5	0	-	-	-	-	-	5	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

quite possible that male weakfish prefer a specific salinity range, deeper channels, or remain in offshore waters near shore waiting for females to move seaward to spawn. These theories cannot be validated from this study's data.

The number and percentage of female versus male weakfish by salinity level from which they were collected are presented in Table 66. The percentage for all weakfish collected was 86% females and 14% males. There was little difference in the percent occurrence of female and male weakfish at different salinities in inshore waters as males never comprised over 20% at any salinity level.

Female weakfish outnumbered males in all months, and comprised over 83% of the catch in all months except July (62%) and December (70%).

Fish length-fecundity relationship equations for North Carolina weakfish were reported by Merriner (1976). Using his equation for total length, the estimated fecundity for 350 and 500 mm weakfish were 799,400 and 2,051,100 eggs, respectively. Additional detailed fecundity information is limited for populations from the more southerly waters.

As shown in Table 40, very few advanced reproductive stages (stages IV-VII) were collected in the estuarine waters of Glynn County, Georgia. In general, Georgia weakfish spawn in ocean waters beyond the sampling area of this study. Therefore, very few ripe weakfish were collected for fecundity analyses. Fecundity estimates were determined for three weakfish ranging in length, weight, and age from 344 to 373 mm, 450 to 861 g, and III to IV years. Mean estimated fecundity was 151,824 eggs with a range from approximately 115 to 171 thousand. The average total weight of the three specimens was 702 g with the gonads comprising 13% (90.9 g) of the fish weights.

Food Preference and Feeding Habits

Of the 326 weakfish stomachs analyzed to determine food preferences, 240 (73.6%) contained food and 86 (26.4%) were empty (Table 67). In

Table 66. Number and percent of female versus male weakfish, *Cynoscion regalis*, by salinity gradient and month for fish collected in Glynn County, Georgia from January 1979 through June 1982.

MONTH		SURFACE WATER SALINITY (0/00) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	36-40 F	36-40 M	TOTAL F	TOTAL M
January	No.									19	1	7	0					26	1
	%									95	5	100	0					96	4
February	No.							8	0	1	0	21	0					30	0
	%							100	0	100	0	100	0					100	0
March	No.					3	0	23	2	3	1	3	3					32	6
	%					100	0	92	8	75	25	50	50					84	16
April	No.					1	0	2	0	3	1	10	2	5	0			21	3
	%					100	0	100	0	75	25	83	17	100	0			87	13
May	No.							5	0	4	1	6	0					15	1
	%							100	0	80	20	100	0					94	6
June	No.											1	2	28	2			29	4
	%											33	67	93	7			88	12
July	No.											2	1	14	9			16	10
	%											67	33	61	39			62	38
August	No.									1	0	2	0					3	0
	%									100	0	100	0					100	0
September	No.							8	3	4	0	11	2	2	0			25	5
	%							73	27	100	0	85	15	100	0			83	17
October	No.							11	2	2	0	1	0					14	2
	%							85	15	100	0	100	0					87	13
November	No.							1	0			19	1	3	0			23	1
	%							100	0			95	5	100	0			96	4
December	No.									18	10	5	0					23	10
	%									64	36	100	0					70	30
TOTALS	No.					4	0	58	7	55	14	88	11	52	11			257	43
	%					100	0	89	11	80	20	89	11	83	17			95	5

Table 67. Stomach contents of weakfish, *Cynoscion regalis*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group (mm) 1-100	101-200	201-300	301-400	401-500	501-600	Combined	Percent Occurrence	Average % Bolus
PISCES									
Pisces (unidentifiable)	1	22	29	49	5		106	44.2	70
Anchoa hepsetus		1					1	0.4	90
Anchoa mitchilli		1	4	1			6	2.5	83
Brevoortia tyrannus			6	44	1	1	52	21.7	84
Chloroscombrus chrysurus				1			1	0.4	40
Leiostomus xanthurus				1			1	0.4	90
Menidia menidia			1				1	0.4	90
Menticirrhus americanus				1			1	0.4	90
Menticirrhus littoralis			1				1	0.4	60
Stellifer lanceolatus			5	5	1		11	4.6	76
ARTHROPODA									
Crustacea (unidentifiable)		5	3	9			17	7.1	56
Alpheus heterochelis			1	2			3	1.3	57
Anthuridae			1				1	0.4	90
Cyathura polita				2			2	0.8	90
Decapoda	1	4	4	1			10	4.2	69
Neomysis americana	2	8	1	14			25	10.4	57
Ostracoda				1			1	0.4	< 5
Palaemonetes		2					2	0.8	85
Penaeidae			1	3	2		6	2.5	55
Penaeus setiferus			8	7			15	6.3	84
Trachypenaeus constrictus				3			3	1.3	30
CEPHALOPODA									
Cephalopoda (unidentifiable)		1		2			3	1.3	53
Lolliguncula brevis			1	3			4	1.7	63
ANNELIDA									
Nicolea simplex	1	1					2	0.8	35
PLANT									
Detritus		3	1	2			6	2.5	90
Spartina alterniflora		3		1	1		5	2.1	54
INORGANIC MATERIAL				6	1		7	2.9	82

Number of stomachs: 326
Number and percent of stomachs containing food: 240 (73.6%)
Number and percent of empty stomachs: 86 (26.4%)

weakfish <200 mm there was nearly equal utilization of crustaceans and fish. Mysid shrimp were the dominant crustacean and anchovies (*Anchoa mitchilli* and *Anchoa hepsetus*) were the primary fishes utilized as food. In 201-400 mm specimens major food items shifted to menhaden (*Brevoortia* sp.) as the top fish species, and penaeid shrimp (*Penaeus setiferus* and *Trachypeneus constrictus*) and mysid shrimp were the dominant crustaceans. For adult weakfish over 400 mm there was approximately equal utilization of menhaden and penaeid shrimp. By far, these two species are of major importance as food for Georgia weakfish.

Other investigations along the Atlantic coast observed butterfish, herrings, sand lance, silversides, anchovies, young weakfish, Atlantic croaker, spot, scup and killifish as the most frequently occurring fish as food. Among the invertebrates were assorted shrimp, squids, crabs, annelid worms and clams (Wilk, 1979). Mahood (1974) found the major foods for Georgia weakfish to be fish (80.6%), shrimp (14.3%), and squid (5.7%). He also found that anchovies dominated the fishes utilized by smaller weakfish while menhaden were dominant in larger specimens. This is in agreement with our findings presented above.

The 10 most frequently occurring food items in weakfish stomachs by season and sector are presented in Table 68. Fish were the most frequently occurring food item in all seasons and all sectors. Menhaden were the most commonly ingested fish, occurring in 21.7% of the stomachs, while mysid shrimp were the most common invertebrate in 10.4%.

In the creeks white shrimp (*Penaeus setiferus*) and star drum (*Stellifer lanceolatus*) were the dominant food species. In the sounds, the dominant food items were menhaden and mysid shrimp, while on the beaches star drum and mysid shrimp were dominant. The one specimen collected from the offshore waters contained only mysid shrimp in its stomach.

During winter, mysid shrimp were the most dominant forage species although fish and fish parts were found. The most commonly ingested fish during winter were menhaden and star drum. In spring, fish were the dominant food with menhaden as the dominant species although mysid

Table 68. The 10 most frequently occurring food items found in the stomachs of weakfish, *Cynoscion regalis*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Sector	Winter Food Item	Winter No. Stomachs	Winter Percent Occurrence	Winter Average % Bolus	Spring Food Item	Spring No. Stomachs	Spring Percent Occurrence	Spring Average % Bolus	Summer Food Item	Summer No. Stomachs	Summer Percent Occurrence	Summer Average % Bolus
Creeks	Pisces	1	100.0	90	Pisces	5	83.3	78	Pisces	2	50.0	50
	Alpheus sp.	1	100.0	10	Decapoda	1	16.7	90	*Anchoa mitchilli*	1	25.0	90
	Ostracoda	1	100.0	<5	*Alpheus* sp.	1	16.7	70	Mysidae	1	25.0	90
					Crustacea	1	16.7	20	*Palaemonetes* sp.	1	25.0	80
									Annelida	1	25.0	20
Sounds	Pisces	18	31.6	86	Pisces	24	75.0	81	*Brevoortia tyrannus*	33	48.5	82
	Mysidae	17	29.8	85	*Brevoortia tyrannus*	4	12.5	90	Pisces	23	33.8	40
	Crustacea	9	15.8	71	*Spartina alterniflora*	4	12.5	55	*Anchoa mitchilli*	5	7.4	82
	Unidentified material	5	8.8	90	Mysidae	3	9.4	30	Decapoda	5	7.4	74
	Brevoortia tyrannus	3	5.3	90	Plant detritus	2	6.3	90	*Lolliguncula brevis*	3	4.4	70
	Stellifer lanceolatus	3	5.3	83	Crustacea	1	3.1	60	Crustacea	3	4.4	47
	Decapoda	2	3.5	60	Unidentified material	1	3.1	40	*Penaeus setiferus*	1	1.5	90
	Penaeus setiferus	1	1.8	90	Decapoda	1	3.1	20	*Palaemonetes* sp.	1	1.5	90
	Cyathura polita	1	1.8	90	Cephalopoda	1	3.1	<5	Mysidae	1	1.5	90
	Menidia menidia	1	1.8	90					Anthuridae	1	1.5	90
Beaches	NONE 1/	-	-	-	Pisces	9	100.0	72	*Stellifer lanceolatus*	1	100.0	100
					Menticirrhus americanus	1	11.1	90				
					Cephalopoda	1	11.1	80				
					Trachypeneus constrictus	1	11.1	<5				
Offshore	Mysidae	1	100.0	90	NONE	-	-	-	NONE	-	-	-
Totals	Pisces	19	32.2	86	Pisces	38	80.9	79	*Brevoortia tyrannus*	33	45.2	82
	Mysidae	18	30.5	85	*Brevoortia tyrannus*	4	8.5	90	Pisces	25	34.2	41
	Crustacea	9	15.3	71	*Spartina alterniflora*	4	8.5	55	*Anchoa mitchilli*	6	8.2	83
	Unidentified material	5	8.5	90	Mysidae	3	6.4	30	Decapoda	5	6.8	74
	Brevoortia tyrannus	3	5.1	90	Plant detritus	2	4.3	10	*Lolliguncula brevis*	3	4.1	70
	Stellifer lanceolatus	3	5.1	83	Decapoda	2	4.3	55	Crustacea	3	4.1	47
	Decapoda	2	3.4	60	Cephalopoda	2	4.3	40	Mysidae	2	2.7	90
	Alpheus sp.	2	3.4	50	Crustacea	2	4.3	30	*Palaemonetes* sp.	2	2.7	85
	Leiostomus xanthurus	1	1.7	90	*Menticirrhus americanus*	1	2.1	90	Anthuridae	1	1.4	90
	Cyathura polita	1	1.7	90	*Alpheus* sp.	1	2.1	70	*Penaeus setiferus*	1	1.4	90

1/ None denotes no specimens were collected with food in stomachs.

Table 68. (continued)

Sector	Fall: Food Item	Fall: No. Stomachs	Fall: Percent Occurrence	Fall: Average % Bolus	Combined Totals: Food Item	Combined Totals: No. Stomachs	Combined Totals: Percent Occurrence	Combined Totals: Average % Bolus
Creeks	*Penaeus setiferus*	7	63.6	84	Pisces	10	45.5	76
	Pisces	2	18.2	90	*Penaeus setiferus*	7	31.8	84
	Stellifer lanceolatus	2	18.2	45	*Stellifer lanceolatus*	2	9.1	45
	Anchoa hepsetus	1	9.1	90	*Alpheus* sp.	2	9.1	40
	Menticirrhus littoralis	1	9.1	60	*Anchoa hepsetus*	1	4.5	90
					Anchoa mitchilli	1	4.5	90
					Mysidae	1	4.5	90
					Decapoda	1	4.5	90
					Palaemonetes sp.	1	4.5	80
					Menticirrhus littoralis	1	4.5	60
Sounds	Pisces	19	43.2	72	Pisces	84	41.8	69
	Brevoortia tyrannus	11	25.0	27	*Brevoortia tyrannus*	51	25.4	84
	Penaeus setiferus	7	15.9	83	Mysidae	22	10.9	75
	Penaeidae	5	11.4	56	Crustacea	15	7.5	61
	Stellifer lanceolatus	4	9.1	80	*Penaeus setiferus*	9	4.5	84
	Crustacea	2	4.5	35	Decapoda	9	4.5	67
	Decapoda	1	2.3	90	Unidentified material	6	3.0	82
	Cyathura polita	1	2.3	90	Penaeidae	6	3.0	55
	Organic material	1	2.3	90	*Anchoa mitchilli*	5	2.5	82
	Plant detritus	1	2.3	90	*Spartina alterniflora*	5	2.5	54
Beaches	Pisces	3	50.0	77	Pisces	12	75.0	73
	Brevoortia tyrannus	1	16.7	90	*Stellifer lanceolatus*	2	12.5	90
	Stellifer lanceolatus	1	16.7	90	Mysidae	1	6.3	90
	Mysidae	1	16.7	90	*Menticirrhus americanus*	1	6.3	90
	Crustacea	1	16.7	50	*Brevoortia tyrannus*	1	6.3	80
					Cephalopoda	1	6.3	80
					Crustacea	1	6.3	50
					Trachypeneus constrictus	1	6.3	<5
Offshore	NONE [1/]	-	-	-	Mysidae	1	100.0	90
Totals	Pisces	24	39.3	74	Pisces	106	44.2	70
	Penaeus setiferus	14	23.0	84	*Brevoortia tyrannus*	52	21.7	84
	Brevoortia tyrannus	12	19.7	88	Mysidae	25	10.4	77
	Stellifer lanceolatus	7	11.5	71	Crustacea	17	7.1	56
	Penaeidae	5	8.2	56	*Penaeus setiferus*	16	6.7	84
	Crustacea	3	4.9	40	*Stellifer lanceolatus*	11	4.6	76
	Mysidae	2	3.3	60	Decapoda	10	4.2	69
	Decapoda	1	1.6	90	*Anchoa mitchilli*	6	2.5	83
	Cyathura polita	1	1.6	90	Unidentified material	6	2.5	82
	Plant material	1	1.6	90	Penaeidae	6	2.5	55

[1/] None denotes no specimens were collected with food in stomachs.

shrimp were also ingested. In summer the major foods were menhaden, anchovies, squids and crustaceans. In fall the major foods were white shrimp, menhaden and star drum. The second shift in major food items indicated that weakfish were highly opportunistic feeders.

Feeding activity, as related to the number of stomachs containing food, was greatest during spring and summer as over 81% of the stomachs contained food (Table 69). In fall there was a slight decline in feeding activity as the percentage of stomachs containing food dropped to 69.3%. Lowest feeding activity occurred in winter when only 62.8% contained food.

Feeding activity was greatest in the creeks (84.6% contained food) and lowest on the beaches (64.0%), with the sounds midway between (73.4%). No conclusions are drawn for offshore waters as only one specimen was examined from the sector.

At water temperatures below 15°C over 40% of the stomachs examined were empty, indicating decreased feeding activity or low food availability or both (Table 50). As water temperatures increased to 21°C, the percentage of empty stomachs dropped below 16%, and at temperatures above 21°C only 5% of the stomachs were empty. These figures indicate that feeding activity was greatest and food was most abundant during summer when water temperatures were highest.

Weakfish are voracious feeders. Study results reveal that this species fed actively throughout the lunar cycle as 73.6% of all stomachs examined contained food (Table 51). Peak feeding activity occurred during first quarter moon and three days immediately thereafter, and during the three day period prior to last quarter as over 83% of the stomachs contained food. Periods of lowest feeding activity occurred on full moon and during the three days following as only 54% of the stomachs contained food. High turbidity during full moon probably resulted in prey being more difficult to capture.

Fish were the most common food item for weakfish during all seasons with *Brevoortia tyrannus* the most common species. Mysids were the most common crustaceans consumed by weakfish. *B. tyrannus* was the 15th most

Table 69. Number and percent of weakfish, *Cynoscion regalis*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	1	33.3	2	66.7	3	100.0	57	64.8	31	35.2	88	100.0	0	0.0	2	100.0	2	100.0
Spring	6	85.7	1	14.3	7	100.0	32	86.5	5	13.5	37	100.0	9	64.3	5	35.7	14	100.0
Summer	4	100.0	0	0.0	4	100.0	68	84.0	13	16.0	81	100.0	1	100.0	0	0.0	1	100.0
Fall	11	91.7	1	8.3	12	100.0	44	64.7	24	35.3	68	100.0	6	75.0	2	25.0	8	100.0
Total	22	84.6	4	15.4	26	100.0	201	73.4	73	26.6	274	100.0	16	64.0	9	36.0	25	100.0

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	1	100.0	0	0.0	1	100.0	59	62.8	35	37.2	94	100.0
Spring	-	-	-	-	-	-	47	81.0	11	19.0	58	100.0
Summer	-	-	-	-	-	-	73	84.9	13	15.1	86	100.0
Fall	-	-	-	-	-	-	61	69.3	27	30.7	88	100.0
Total	1	100.0	0	0.0	1	100.0	240	73.6	86	26.4	326	100.0

abundant fish species and Mysidae the fourth most abundant crustacean collected in three meter trawl samples (Table 54). Therefore, preference may be more intense for *B. tyrannus* than for Mysids. Other food items which were common in weakfish stomachs included *Stellifer lanceolatus* and *Penaeus setiferus*. Both of these food items were common in trawl samples, indicating a random feeding selection or preference for these species.

RED DRUM

Red drum (*Sciaenops ocellatus*) range from Laguna Madre, Mexico to south Florida in the Gulf of Mexico and along the Atlantic coast from south Florida to New York (Fischer, 1978).

Younger red drum, less than four years of age, commonly inhabit Georgia's inside waters in areas similar to that of spotted seatrout. Also, when marshlands are inundated during flood tides, they often move into these submerged areas to feed. Older red drum are commonly found in the surf zones on sandy beaches and in shoal areas associated with the mouths of major river systems such as the Altamaha River. During spawning, it is generally believed that older red drum move to offshore waters, possibly over live bottom areas.

Movement and Migration

From March 3, 1979 through June 22, 1982, 368 red drum were tagged and released. Length frequencies of tagged red drum in 50 mm length groups are included in Table 70. Lengths (TL) of tagged red drum ranged from 257 to 996 mm for those tagged with Howitt tags and 264 to 1,045 mm for those tagged with Floy tags. Length frequencies of red drum tagged with each tag type are shown in Table 71. Of 368 specimens tagged, 38 were tagged with both tag types in order to compare and evaluate tag retention. Table 72 lists the length frequencies of tagged red drum in 20 mm length groups by gear type.

Tagged red drum were returned from August 22, 1979 through July 25, 1983. Of 368 tagged, 79 (21.5%) were recaptured and tags returned.

Table 70. Number tagged, number and percent recaptured, days at large and distance traveled for red drum, *Sciaenops ocellatus*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large		Distance Traveled (km) 1/	
				Avg.	Max.	Avg.	Max.
251 - 300	25	5	20.0	88	214	48.0	178
301 - 350	135	39	28.9	162	1104	17.5	161
351 - 400	65	17	26.2	198	456	6.9	108
401 - 450	60	15	25.0	163	376	4.9	49
451 - 500	19	2	10.5	225	347	0.0	0
501 - 550	3	0	0.0				
551 - 600	20	0	0.0				
601 - 650	26	1	3.8	233	233	5.6	6
651 - 700	6	0	0.0				
701 - 750	6	0	0.0				
751 - 800	1	0	0.0				
951 - 1000	1	0	0.0				
1001 - 1050	1	0	0.0				
Total	368	79	21.5	168	1,104	14.2	178

1/ Distance measured in kilometers from point of release to point of recapture.

Table 71. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for red drum, *Sciaenops ocellatus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
275	20	4	20.0	2			22	4	18.2
325	124	36	29.0	10			134	36	26.9
375	55	16	29.1	1			56	16	28.6
425	39	11	28.2	5			44	11	25.0
475	15	2	13.3	2			17	2	11.8
525	1			1			2		
575	10			8			18		
625	14	1	7.1	9			23	1	4.3
675	6						6		
725	5			1			6		
975	1						1		
1025				1			1		
Total	290	70	24.1	40	0	0.0	330	70	21.2

NOTE: Number tagged and recaptured does not include the 38 fish tagged with both tag types.

Table 72. Number of red drum, *Sciaenops ocellatus*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Gill Net (in)[1/]					Trammel Net	Cast Net	Hook/Line	Totals
	2	2-7/8	3-1/2	4-5/8	6				
250	-	1	-	-	-	-	-	-	1
270	1	5	-	-	-	-	-	1	7
290	1	14	-	-	-	-	-	2	17
310	-	43	-	-	-	1	-	3	47
330	-	53	1	-	-	1	-	1	56
350	-	36	-	-	-	4	-	4	44
370	-	14	-	-	-	5	-	3	22
390	-	7	1	-	-	20	1	1	30
410	-	7	-	-	-	26	-	2	35
430	-	3	2	-	1	12	1	-	19
450	1	4	-	-	-	11	-	1	17
470	-	-	-	-	-	5	-	-	5
490	-	-	-	-	1	1	1	-	3
510	-	-	1	-	-	1	-	-	2
530	-	-	-	-	-	-	-	-	-
550	-	-	-	1	-	-	-	-	1
570	1	4	-	-	2	1	-	-	8
590	1	4	-	-	1	6	-	-	12
610	1	-	-	-	3	8	-	-	12
630	1	1	-	-	2	3	-	-	7
650	-	2	-	-	3	6	-	-	11
670	-	1	-	-	-	1	-	-	2
690	-	-	-	-	1	-	-	-	1
710	-	1	-	-	1	-	-	-	2
730	-	2	-	-	1	-	-	-	3
750	-	1	-	-	-	1	-	-	2
770	-	-	-	-	-	-	-	-	-
790	-	-	-	-	-	-	-	2	2
Totals	7	203	5	1	16	113	3	20	368

[1/]Gill net sizes are stretch mesh measurements.

Recovery rates, when separated into 50 mm length groups, ranged as high as 28.9%. Table 70 presents the number of fish released and recaptured, time at large, and distance traveled. Time at large ranged from 2 to 1,104 days with an average at large time of 168 days. Maximum distance traveled was 178 km with an average of 14.2 km.

The overall recovery rate with Howitt tags was 24.1% while Floy tags failed to produce any recoveries (Table 71). Of 38 red drum tagged with both tag types, 9 (23.7%) were recovered. Six of these nine recoveries were at large from 6 to 85 days and had both tag types attached. The remaining three double-tagged red drum were at large 216 to 641 days and only the Howitt tag remained attached.

Recreational fishermen were the major source of red drum recoveries, accounting for 71 (89.9%) of the 79 returns. Study activities accounted for 8 (10.1%) while commercial fishermen failed to return any recaptures (Table 11). Of 71 recreational recaptures, 41 (58%) included sufficient information to determine lengths of creel-size fish. Lengths (TL) of recreational recaptures ranged from 311 to 659 mm and averaged 447 mm (Table 14). Larger red drum were tagged, but only one was recaptured. This fish was tagged in the sound sector and recaptured on the beach in September after being at large 641 days. Unfortunately, recapture length was not available for this individual. However, it had measured 642 mm when released, and it weighed approximately 7.3 kg when recaptured. From our length-weight curves the estimated length when recaptured was approximately 900 mm (Figure 24). Large catches of adult red drum on Georgia's beaches and shoals were not uncommon in the past, but reported catches have decreased dramatically in the last 5 to 10 years. Recoveries indicated that recreational fishermen fishing inland waters were likely to catch red drum ranging from 300 to 700 mm (Table 13). However, reds greater than 750 mm tended to move to areas of higher salinities in beach, shoal, and offshore waters. These areas generally receive less fishing pressure than the inside waters.

Of 79 recoveries, 71 produced sufficient information to determine the estuarine sector, location and season of recapture. The sounds had the highest return rate (83.1%). Approximately the same percentage was recaptured in the sounds as was released (Table 14). Creek and beach sectors together produced the remaining recoveries (16.9%). Although larger specimens occur offshore during fall and winter, this area failed to produce any recoveries. Recovery data indicated that red drum were most abundant in the inside waters during summer and fall. Inside waters accounted for approximately 96% of all red drum recoveries (Table 15).

Georgia residents fishing in state waters accounted for 67 (94%) of the 71 recreational recoveries. Of these resident fishermen 53 (79%) traveled 40 km or less to reach the location of recapture and approximately 91% traveled less than 160 km (Table 16).

The principal bait used by recreational fishermen to catch red drum was shrimp. Approximately 87% of all recreational red drum recaptures were caught on live shrimp with an additional 9.8% being taken on dead shrimp (Table 17). Artificial lures and cut bait (mullet) accounted for the remaining two recoveries.

Approximately 62% of the recoveries were caught in the immediate area of release. Of 79 recoveries, 70 (88.6%) were recaptured within 25 km of the tagging site. Four recoveries (5.1%) had moved from 26 to 100 km, and five (6.3%) had traveled over 100 km from the point of release (Table 73). The distance traveled and time at large for nine red drum that traveled over 25 km ranged from 49 to 178 km and 47 to 215 days. The average release length of these individuals was 334 mm. Four of these were recaptured during the fall and exhibited an average northward movement at 112.5 km. The greatest northward movement (161 km) was to St. Helena Island, South Carolina. The other five individuals exhibited an average southward movement of 112.2 km with the greatest movement (178 km) to the jetties at St. Augustine, Florida. The individuals that moved southward were recaptured during fall, winter and spring. In general, winter was the period of greatest movement, averaging 30.8 km (Table 21). Only 5 (6.3%) were recaptured beyond Georgia waters. Also, 72% of the drum that moved out of Georgia estuaries were recovered during the fall season.

Table 73. Days at large and distance traveled for red drum, *Sciaenops ocellatus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Days At Large	Distance Traveled (km)							Total	Percent
	0	0.1-1	1-5	6-25	26-50	51-100	101-200		
1 - 50	20	1	3	2	-	2	1	29	36.7
51 - 100	7	1	-	3	-	1	2	14	17.7
101 - 150	3	1	-	-	-	-	1	5	6.3
151 - 200	1	1	-	-	-	-	-	2	2.5
201 - 300	6	3	2	2	1	-	1	15	19.0
301 - 500	10	-	-	2	-	-	-	12	15.2
501 - 750	1	-	-	-	-	-	-	1	1.3
750 - 1,000	-	-	-	-	-	-	-	-	-
Over 1,000	1	-	-	-	-	-	-	1	1.3
Total	49	7	5	9	1	3	5	79	100.0
Percent	62.0	8.9	6.3	11.4	1.3	3.8	6.3	100.0	

Recovery information was insufficient to ascertain seasonal movement trends within the estuary. Movement within the estuary appeared to be random during spring, summer and fall, and very little movement was observed during winter (Table 74). Similar movement behavior was reported for red drum in Texas bays (Simmons and Breuer, 1962).

In Florida, Beaumariage (1969) reported 91.2% of the red drum recoveries did not move significantly from their release locations. Approximately 89% of the recovered Texas red drum moved less than 25 km (Matlock and Weaver, 1979). Simmons and Breuer (1962) reported little movement of red drum between Texas bays and even less between bay and gulf.

In general, data indicate that small red drum on the Atlantic and Gulf coasts exhibit little movement. Movement within bays and estuaries appears to be random, usually being initiated by changing climatic conditions. Larger red drum generally move to beach and offshore waters and seldom return to the bays or sounds. Understandably, most tagging activities have been conducted in the bays and estuaries where red drum were more abundant, thus limiting the amount of movement, spawning and life history information available for larger red drum.

Length-Weight Relationship

Based on 103 specimens, ranging in length from 32 to 1,099 mm and weight from 1 to 14,336 g, the length-weight relationship for red drum was $\log W = 2.722 \log L - 4.220$. The correlation coefficient value for length-weight for red drum was 0.9776 ($P < 0.0001$). Figure 24 illustrates the length-weight relationship for red drum. Least-squares regression analyses on the relationships between fish length and weight for male, female, and all red drum combined are shown in Table 24. The greatest lengths recorded for male and female red drum during this study were 776 and 1,099 mm, respectively. The heaviest specimens were a 4,152 g male and a 14,336 g female. The weights of Georgia red drum are compared with fish from other areas in Table 75.

Table 74. Seasonal movement of red drum, *Sciaenops ocellatus*, tagged in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

		Direction Moved By Recaptured Tagged Fish				
	Length Group	Caught In Area	Movement Within Estuary		Movement Out Of Estuary	
Season	(mm)	Of Release	Creek to Beach	Beach To Creek	North	South
Winter	251-300	-	-	-	-	1
	301-350	3	-	-	-	-
	351-400	2	-	-	-	-
	401-450	4	-	-	-	-
	451-500	-	-	-	-	-
	501-550	-	-	-	-	-
	551-600	-	-	-	-	-
	601-650	-	-	-	-	-
	Total	9	-	-	-	1
	Percent	90.0	-	-	-	10.0
Spring	251-300	-	-	-	-	1
	301-350	-	-	1	-	-
	351-400	1	-	-	-	-
	401-450	3	1	-	-	-
	451-500	-	-	-	-	-
	501-550	-	-	-	-	-
	551-600	-	-	-	-	-
	601-650	-	-	-	-	-
	Total	4	1	1	-	1
	Percent	57.1	14.3	14.3	-	14.3
Summer	251-300	-	2	1	-	-
	301-350	14	-	1	-	1
	351-400	4	-	1	-	2
	401-450	2	-	-	-	-
	451-500	-	-	-	-	-
	501-550	-	-	-	-	-
	551-600	-	-	-	-	-
	601-650	-	1	-	-	-
	Total	20	3	3	-	3
	Percent	69.0	10.3	10.3	-	10.3
Fall	251-300	2	1	1	5	3
	301-350	7	-	1	-	3
	351-400	4	-	1	-	2
	401-450	1	-	-	-	-
	451-500	2	-	-	-	-
	501-550	-	-	-	-	-
	551-600	-	-	-	-	-
	601-650	-	-	-	-	-
	Total	16	1	3	5	8
	Percent	48.5	3.0	9.1	15.2	24.2
Combined	Total	49	5	7	5	13
	Percent	62.0	6.3	8.9	6.3	16.5

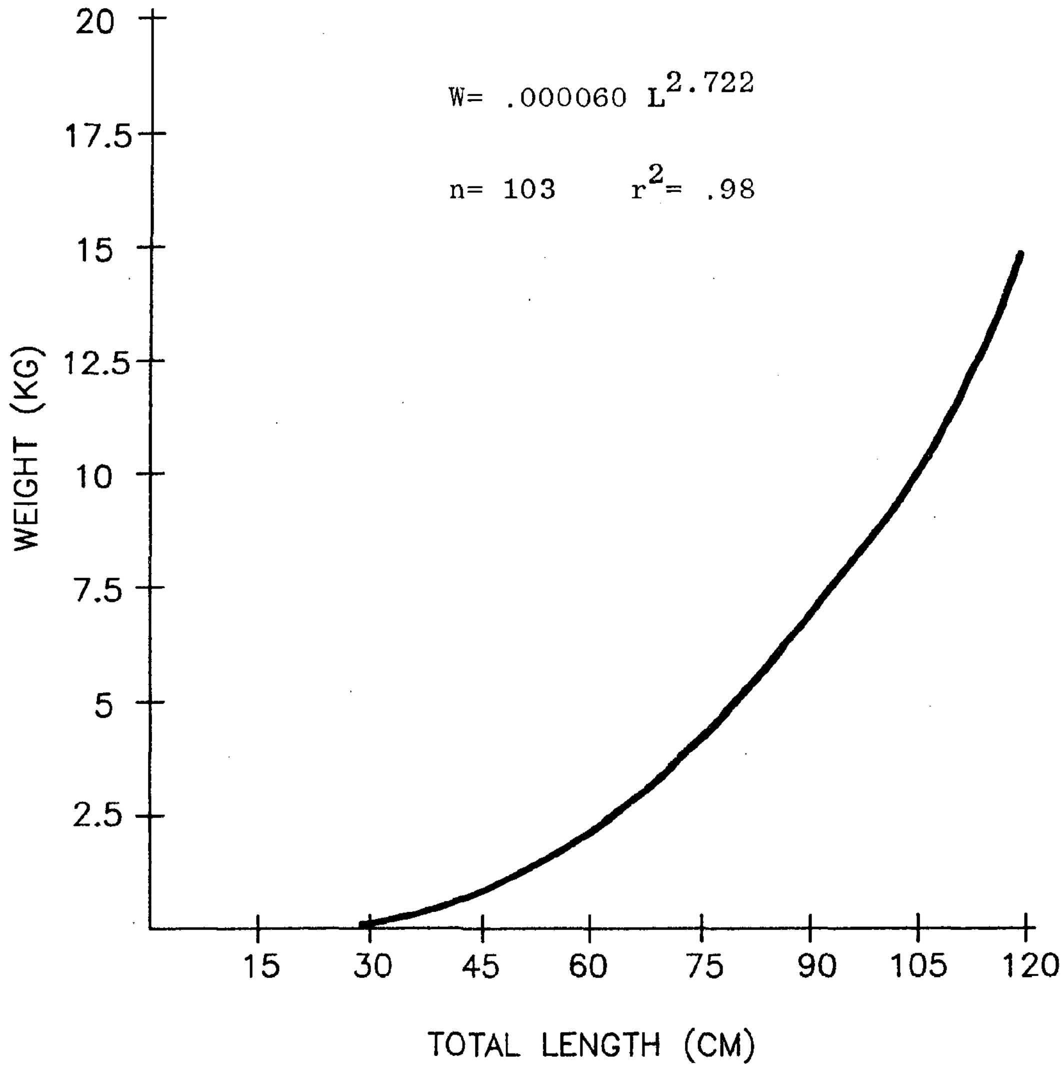

Figure 24. Length-weight relationship of red drum, *Sciaenops ocellatus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Table 75. Comparison of total length-weight relationships for several populations of red drum, *Sciaenops ocellatus*.

Study	Location	Length - Weight Equation	Weight of Fish (g)		
			350 mm	500 mm	750 mm
Boothby and Avault (1971)	Louisiana	$\log W = 2.832 \log L - 4.422$ 1/	401	1,098	3,469
Theiling (1974)	South Carolina	$\log W = 2.740 \log L - 1.296$ 2/	564	1,613	4,692
Hein *et al* (1980)	Louisiana	$\log W = 3.052 \log L - 5.120$	442	1,312	4,523
Present Study	Georgia	$\log W = 2.722 \log L - 4.220$	504	1,330	4,011

1/ Equation based on standard length (mm).

2/ Equation based on standard length (cm).

NOTE: Standard lengths converted to total lengths using the formula TL = 1.16 SL.

Age and Growth

Age and growth studies based on length frequencies and scale and otolith techniques have been applied as an ageing method for young red drum (Pearson, 1929; Gunter, 1945; Miles, 1950 and 1951; Simmons and Breuer, 1962; Theiling and Loyacano, 1976; Rohr, 1980). In general, the length frequency method for determination of age was applicable for ageing red drum during the first few years of life, but age of older red drum must be estimated with the use of hard parts. However, as found for both red and black drum, after age IV or V more than one annulus-like mark may be formed on scales and otoliths each year (Richards, 1973; Rohr, 1980). These additional marks may consist of summer and winter annuli and spawning checks (Rohr, 1980).

Scales and otolith sections from 104 red drum ranging from 32 to 1,099 mm were examined. The scales from 90 (87%) individuals were considered legible for age determinations. Ninety-seven percent of the specimens exhibited lengths less than 777 mm. The remaining 3% (3) possessed lengths ranging from 1,060 to 1,099 mm. Both scales and otoliths proved useful for ageing individuals less than 800 mm. However, circuli disconformities and closely spaced annuli made scales unreliable as an ageing structure for larger specimens. Otolith ring counts for the only three large specimens collected in Georgia ranged from 20 to 31 rings. Unfortunately, with such low numbers it was impossible to document when and how many rings were formed each year in order to estimate age of the larger red drum (Figure 25).

Scales and otoliths from smaller individuals (<280 mm) collected during June and August showed no annulus, suggesting that no annulus was formed the first winter. Theiling and Loyacano (1976) reported similar findings for red drum raised in saltwater marsh impoundments in South Carolina. Red drum were approximately 16 months old when the first annulus was formed. Annuli formation on scales and otoliths from red drum collected in Georgia were found to be relatively simultaneous. Calculation of mean monthly growth of marginal increments indicated that

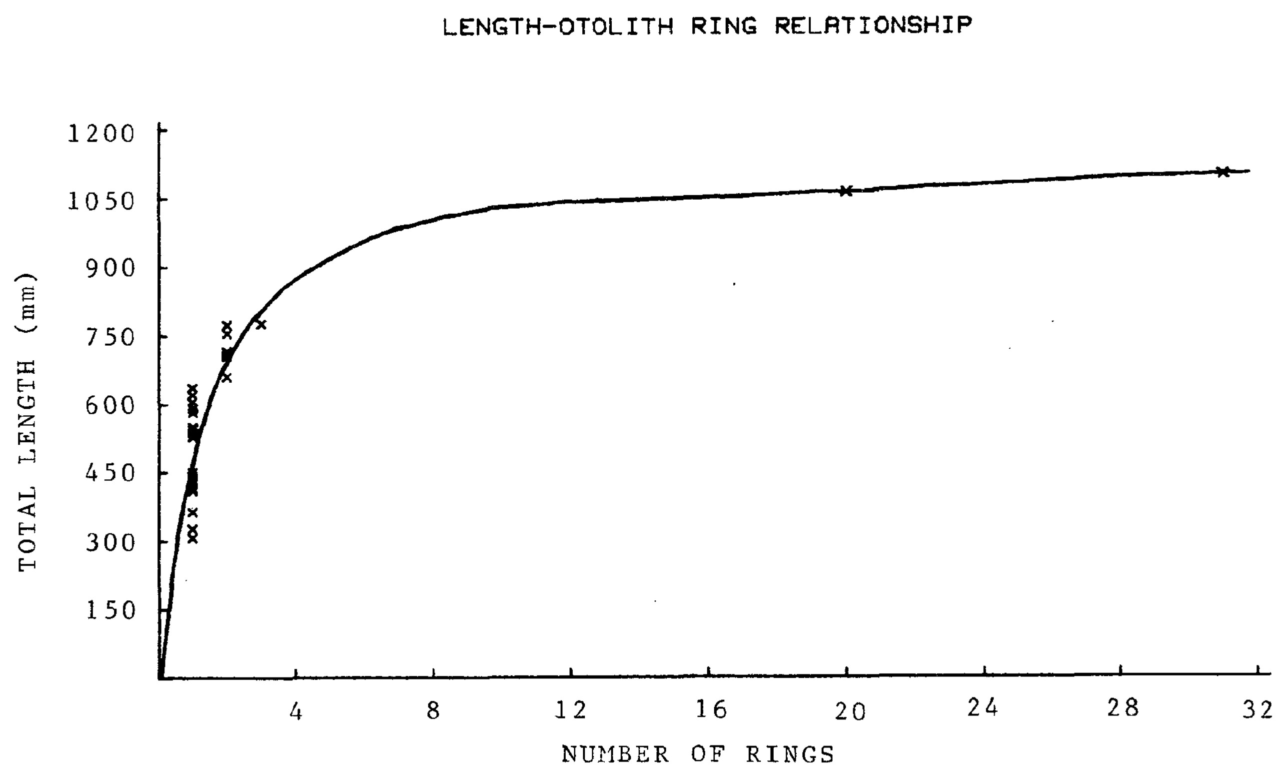

Figure 25. Empirical length/otolith ring relationship for red drum, *Sciaenops ocellatus*, collected in Glynn County, Georgia.

except for the first winter, scale annuli were formed only once annually for at least the first three years of life. A single annulus formation was detectable on young red drum scales from mid-February through April. In an attempt to validate the number of annuli being laid down each year, scale samples from five recaptured red drum were also compared with scale samples taken at the time of release. Unfortunately, only one specimen was at large more than 122 days and possessed additional annuli. This female specimen was tagged August 14, 1981, measured 301 mm, and possessed no scale annuli. It was recaptured February 1, 1984, exhibited a growth increase of 426 mm in 901 days, and possessed two annuli. Such findings indicate only one annulus per year for at least the first three years of life. Due to the recent recapture of this drum in relation to publication of this paper, recovery information was not included in any of the tables. Sufficient numbers of older red drum were not collected to document time of annulus formation or number of annulus-like marks formed each year. Linear regression analyses on the relationship between fish lengths and scale radii yielded a correlation coefficient value of 0.93 ($P < 0.0001$) which suggests back-calculations based on fish length/scale radius would be reliable for estimating fish length at time of annulus formation. The empirical and mean back-calculated total lengths for red drum through Age III are shown in Table 76. Figure 26 illustrates the length-age relationship for young red drum less than four years of age, and Table 77 shows the empirical and weighted mean back-calculated lengths for juvenile, male, female, and combined red drum. Length-age equations for young red drum are shown in Table 27.

Of 11 fish species investigated, red drum exhibited the greatest mean daily growth rate during the first two years of life (Table 32). To substantiate yearly growth of young red drum, the growth rate of tagged specimens at large from 11 to 13 months was compared with annual growth estimates based on back-calculations. Recapture lengths of the seven red drum at large during this one-year interval ranged from 510 to 636 mm with an average of 582 mm which would place the average estimated fish age at approximately 1.5 years. The mean annual growth

Table 76. Mean back-calculated total lengths for red drum, *Sciaenops ocellatus*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back-Calculated Lengths of Successive Scale Rings		
				1	2	3
0	57	32 - 434	298			
1	24	225 - 636	474	378		
2	8	660 - 773	718	463	656	
3	1	776	776	477	630	746
		Weighted Means		403	653	746
		Growth Increments		403	250	93

NOTE: Lengths measured in millimeters.

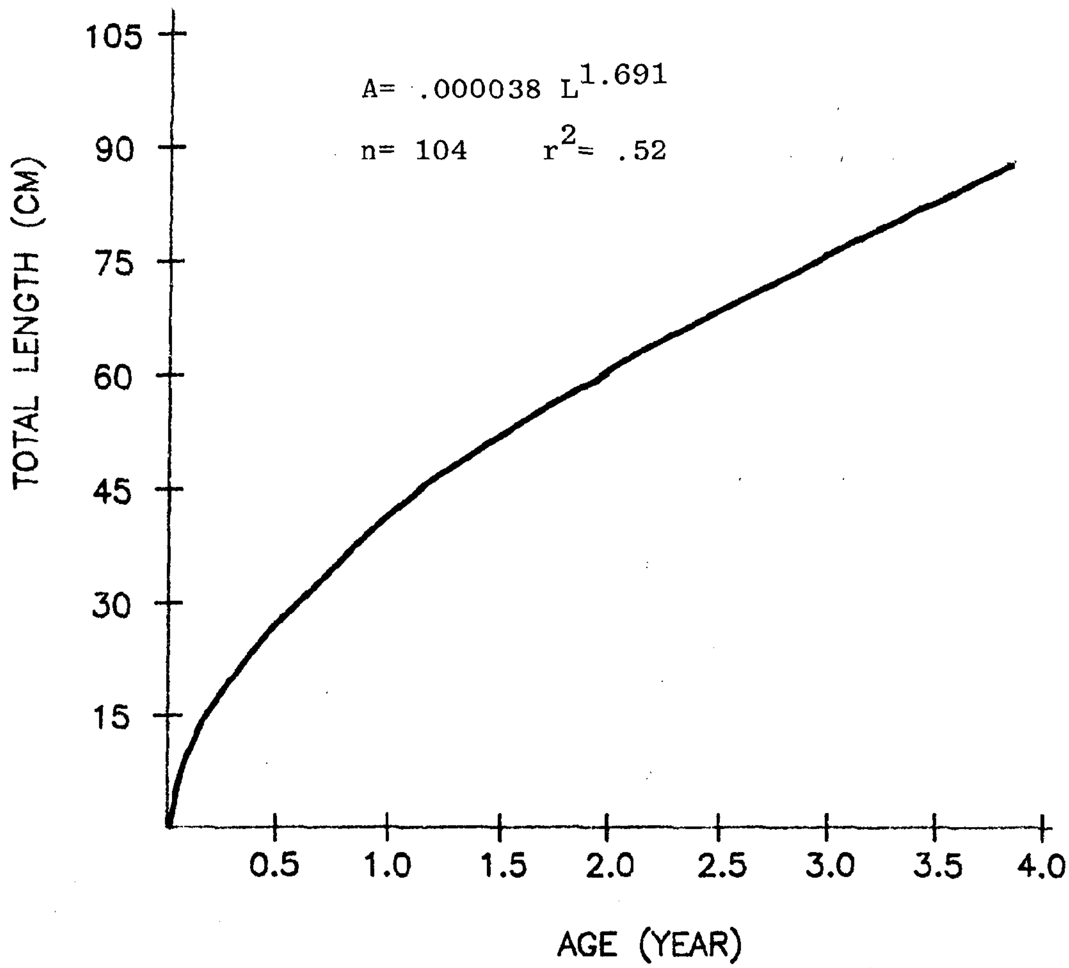

Figure 26. Length-age relationship of red drum, *Sciaenops ocellatus*, collected in Glynn County, Georgia.

Table 77. Number, empirical and back-calculated total lengths, and growth increments by sex and age for red drum, *Sciaenops ocellatus*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Sex	Age 1	2	3
Juveniles			
Number	3		
Mean Length at Capture	373		
Back-Calculated Length	321		
Growth Increment	321		
Males			
Number	9	5	1
Mean Length at Capture	475	711	776
Back-Calculated Length	435	656	746
Growth Increment	435	221	90
Females			
Number	12	3	
Mean Length at Capture	541	731	
Back-Calculated Length	412	645	
Growth Increment	412	233	
Combined			
Number	24	8	1
Mean Length at Capture	474	718	776
Back-Calculated Length	403	653	746
Growth Increment	403	250	93

NOTE: Lengths measured in millimeters.

for seven tagged red drum was 215.7 mm, producing a mean daily growth of 0.59 mm. Estimated daily growth based on back-calculations for drum in their second year of life (Age I) was 0.69 mm, indicating slightly greater growth than was estimated from recapture data (Table 27).

As shown in Table 78, growth rates of Georgia red drum were similar to those reported by investigators in Texas (Pearson, 1929; Gunter, 1945; Miles, 1950 and 1951; Simmons and Breuer, 1962) and South Carolina (Theiling and Loyacano, 1976).

Maturity and Spawning

Adult red drum occur in relatively low numbers in Georgia and are concentrated for the most part in either the beach surf or offshore habitat, depending on season. The greatest known concentration of adults in Georgia is in the surf zone near the mouth of the Altamaha River in the central portion of the Georgia coast. Although adult reds do occur in other locations, their numbers are quite reduced. During the first two years of this study, only the St. Simons and St. Andrew estuaries were sampled. Consequently, the adult red drum were not collected. The Altamaha River area was later included to insure collection of all size groups, but there was an unusually low occurrence of adults during this period and we were unable to collect large specimens. Adults occurred in such low numbers that a local annual red drum "channel bass" tournament on the Altamaha River failed to produce a single tournament entry. The reason for this low occurrence of adults was unknown.

Spawning apparently takes place at sea during fall and early winter during the time when adults have left the surf zone and migrated to open ocean waters. Personal communication with coastal anglers who fish for "stags" indicates that spawning probably takes place in offshore waters as nearly all of these fishermen report a complete absence of advanced maturity in the fish they catch in inland and surf zones. Migrating schools of larger red drum are periodically sighted during the late summer and early fall migration which is probably a prespawn congregation. These surface schools of medium size and large reds are most often

Table 78. Comparison of total lengths at age for several populations of red drum, *Sciaenops ocellatus*.

Study	Location	Estimated Age						
		1	2	3	4	5	6	7
Pearson (1929)	Texas	340	540	640	750	840		
Gunter (1945)	Texas	400	600					
Miles (1950)	Texas	320	510					
Miles (1951)	Texas	-	-	-	-	-	875	925
Simmons and Breuer (1962)	Texas	399	661	873				
Theiling and Loyacano (1976)[1/]	South Carolina	455	606	761	860	885	930	885
Present Study	Georgia	403	653	746				

[1/] Converted from standard lengths using the formula TL=1.247 SL.

NOTE: A dash (-) denotes ages not collected.
Lengths measured in millimeters.

observed in offshore waters from August to October.

One instance of a gravid red drum was taken by recreational anglers from a school of subsurface reds in offshore waters in September 1981, approximately 4 miles southwest of Gray's Reef, a natural live bottom area which lies approximately 16 miles east of Sapelo Island (Captain Ken Murray, personal communication). Four mature prespawning red drum were caught while deep trolling. One "roe" female measured 1,069 mm (42 inches) and weighed 13.01 kg (28.7 lb). Unfortunately, project personnel were not notified of the catch until sometime later and were unable to examine these fish.

Attempts by project personnel to collect large adults failed in every attempt as only nine specimens over 700 mm were collected. The largest specimen was a 1,061 mm "resting" stage female collected in March. Project design and scope partially limited the collection of large reds. Only two large reds were collected during the entire study. The first specimen was tagged and released in April, and the other adult mentioned above was sacrificed for life history study. Both of these fish were collected from the surf zone adjacent to the mouth of the Altamaha River.

No larval or postlarval specimens were identified in ichthyoplankton samples collected during this study (Table 63). However, one juvenile was collected in the 3-meter trawl in Clubbs Creek in St. Simons sound during the winter (Tables 52 and 53). Two young specimens 39 and 54 mm (TL) were collected in mid-July, and four specimens 32 to 86 mm were collected in November. Collection of these young specimens indicates that spawning probably runs from as early as June to as late as December.

The smallest specimens for which sex was determined through gross examination were a 341 mm female and a 315 mm male. Both of these fish were in their second year of life. The smallest stage II female observed was 545 mm (age I), but no stage II males were collected. The only stage IV male collected was an age II specimen 755 mm long.

By compiling information from other investigations, Peret et al. (1980) reported that maturity is reached at 305-381 mm in Alabama, 320-395 mm in Mississippi, and 700-800 mm in Texas, and that ripe fish as small as 425 mm (two years old) had been found by Gunter (1945). Simmons and Breuer (1962) reported that spawning normally occurs at the end of the third or fourth year when the fish are 700-800 mm (SL), but ripe fish as small as 450 mm have been found.

The stages of gonadal development for red drum collected during the study are presented in Table 79. All of the fish collected from February through August exhibited stage I or "resting stage" gonads. Stage II was the most advanced level of gonadal development for females, and these were taken from September through January. The only specimen exhibiting advanced gonadal development (stage IV) was a 755 mm (4.6 kg) male collected inside St. Simons Sound on 2 September 1981 (Table 80). This specimen was collected in 30 ^{o}/oo salinity and 28^{o}C surface water temperature (Table 81).

Peret et al. (1980) summarized the following information on red drum spawning in the Gulf. Along the Florida coast spawning occurs in autumn, probably beginning in September and peaking in October, and the absence of ripe females in Florida estuaries suggests offshore spawning. In Alabama the spawning season was reported as mid-August through December, peaking in mid-September through October near inlets and passes. In Mississippi it begins in September, with mature fish observed only on the Gulf side of barrier islands. In Louisiana spawning occurs from late summer through early fall, and large schools of spawning red drum are reported to congregate around major passes from August through November.

Additional studies are needed on all aspects of red drum life history in Georgia to determine size and age at maturity and spawning as well as actual time and geographic location of the spawning grounds. Future studies must target the largest specimens in offshore waters during early fall and winter to collect information not obtained under the current study.

As shown in Table 40, red drum exhibiting advanced reproductive stages of maturity were virtually absent from collections made in Georgia estuaries. This prohibited the determination of fecundity for

Table 79. Number of red drum, *Sciaenops ocellatus* collected by month, sex and reproductive stage for the period January 1979 through June 1982.

	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
Month	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	4	1	1	0										
February	5	0												
March	1	5												
April	1	1												
May														
June														
July	1	0												
August	3	3												
September	1	10	0	1			0	1						
October	2	4												
November														
December	0	1	1	0										

Table 80. Stages of gonadal development for red drum, *Sciaenops ocellatus*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Month	Reproductive Stage	Surface Water Salinity (0/00) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	36-40 F	36-40 M	Totals F	Totals M
January	I	-	-	-	-	-	-	-	-	3	1	1	0	-	-	-	-	4	1
	II	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I	-	-	-	-	-	-	4	0	-	-	1	0	-	-	-	-	5	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I	-	-	-	-	-	-	0	5	-	-	1	0	-	-	-	-	1	5
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	1	0	-	-	-	-	-	-	-	-	-	-	0	1	-	-	1	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
July	I	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	I	-	-	-	-	-	-	-	-	1	0	1	0	1	3	-	-	3	3
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I	-	-	-	-	0	1	-	-	-	-	1	9	-	-	-	-	1	10
	II	-	-	-	-	-	-	-	-	0	1	-	-	-	-	-	-	0	1
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	0	1	-	-	-	-	0	1
	V-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I	-	-	-	-	-	-	-	-	2	3	0	1	-	-	-	-	2	4
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I	-	-	-	-	-	-	-	-	-	-	-	-	0	1	-	-	0	1
	II	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combined Totals	I	1	0	-	-	0	1	4	5	6	4	6	10	1	5	-	-	18	25
	II	-	-	-	-	-	-	-	-	1	1	1	0	-	-	-	-	2	1
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	0	1	-	-	-	-	0	1
	V-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 81. Stages of gonadal development for red drum, *Sciaenops ocellatus*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)	Reproductive Stage	Surface Water Temperature (°C) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	TOTALS F	TOTALS M
0-5	I	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-10	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-15	I	-	-	-	-	-	-	-	-	-	-	0	1	-	-	0	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-20	I	-	-	4	4	-	-	0	1	-	-	-	-	-	-	4	5
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	3	1	-	-	-	-	0	1	3	2	-	-	6	4
21-25	II	-	-	1	0	-	-	-	-	-	-	0	1	-	-	1	1
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	2	0	-	-	1	0	0	1	3	9	-	-	6	10
	II	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
26-30	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	0	1	-	-	0	1
	V-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-35	I	-	-	0	1	-	-	-	-	0	1	1	2	0	1	1	5
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	9	6	-	-	1	1	1	3	7	14	0	1	18	25
	II	-	-	1	0	1	0	-	-	-	-	0	1	-	-	2	1
TOTALS	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	0	1	-	-	0	1
	V-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

this species. However, fecundity estimates for Texas red drum range from 350,000 to 3,500,000 eggs (Pearson, 1929; Colura, 1974; Johnson et al., 1977).

Food Preference and Feeding Habits

The population of red drum in our study area is relatively small as compared with that of spotted seatrout. Catches of red drum were usually incidental to the collection of other species, and the large adults were extremely difficult to capture even when targeted. All red drum collected were <1,100 mm.

The results of stomach analyses by 100 mm length groups are presented in Table 82. Of 94 stomachs examined 72 (76.7%) contained food and 22 (23.4%) were empty. Small red drum (<300 mm) showed a definite preference for crustaceans with penaeid shrimp, grass shrimp and a variety of mud crabs being the most common foods. As they increased in size (301-800 mm) they began to incorporate more fish into their diets, but crustaceans remained their staple food source. Since only one specimen over 800 mm was collected for stomach analyses, data on the large specimens are lacking. The most commonly ingested crustaceans were white shrimp (*Penaeus setiferus*), mud crabs (*Panopeus herbstii*), and sand fiddler crabs (*Uca pugilator*). The most frequently ingested fish species were mummichogs (*Fundulus heteroclitus*) and striped mullet (*Mugil cephalus*).

With the exception of two specimens collected from the beaches, all specimens were taken from inside waters, primarily from the sounds. From the wide diversity of organisms found in stomachs from inland waters it is apparent that smaller red drum (<800 mm) are opportunistic feeders with a definite preference for shrimp and crabs (Table 82).

Investigations in other states have shown similar results with crustaceans and fish accounting for most of the reported food items in the diet of red drum. The percentages of the various food types varied with geographic location, season and size of fish (Perret et al., 1980). Pearson (1929) reported commercial penaeid shrimp to be the top food

Table 82. Stomach contents of Red Drum, *Sciaenops ocellatus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group (mm) 101-200	201-300	301-400	401-500	501-600	601-700	701-800	1001-1100	Combined	Percent Occurrence	Average % Bolus
PISCES											
Pisces (unidentifiable)	1	2	5	1		2		1	12	16.7	42
Anchoa mitchilli			1						1	1.4	90
Brevoortia tyrannus				1					1	1.4	90
Fundulus heteroclitus			2				1		3	4.2	43
Menidia menidia				1					1	1.4	80
Micropogonias undulatus						1			1	1.4	80
Mugil cephalus			1		1	1			3	4.2	80
Ophichthus ophis							1		1	1.4	30
Opsanus tau				1			1		2	2.8	65
Syngathidae					1				1	1.4	90
ARTHROPODA											
Crustacea (unidentifiable)		2	2	1	2			1	8	11.1	41
Alpheus heterochelis				2					2	2.8	15
Anthuridae		1	2	2					5	6.9	43
Callianassa atlantica						1			1	1.4	70
Callinectes sapidus			2	2					4	5.6	83
Caprellidae							1		1	1.4	30
Crangon septemspinosa			1						1	1.4	90
Cyathura polita			2				1		3	4.2	70
Eurypanopeus depressus			1	1					2	2.8	30
Hexapanopeus angustifrons			1						1	1.4	10

Table 82. (continued)

Food Item	Length Group (mm)									Percent Occurrence	Average % Bolus
	101-200	201-300	301-400	401-500	501-600	601-700	701-800	1001-1100	Combined		
ARTHROPODA (continued)											
Natantia			2				2		4	5.6	50
Palaemonetes sp.		1	2	3					6	8.3	38
Panopeus herbstii		1	4		3		3		11	15.3	55
Penaeus aztecus		1							1	1.4	40
Penaeus setiferus		1	8	1	1				11	15.3	82
Penaeidae						1			1	1.4	20
Portunus gibbesii					1				1	1.4	90
Rhithropanopeus harrisii							2		2	2.8	20
Sesarma cinereum				1					1	1.4	10
Sesarma reticulatum		1	2				1		4	5.6	35
Squilla empusa			1						1	1.4	80
Trachypeneus constrictus		1							1	1.4	10
Uca pugilator		2	7	1					10	13.9	63
Uca pugnax		1	6						7	9.7	73
ANNELIDA											
Nicolea simplex		1							1	1.4	90
PLANT											
Detritus		2	5						7	9.7	40
Spartina alterniflora				1			1		2	2.8	15

Number of stomachs: 94
Number and percent of stomachs containing food: 72 (76.6%)
Number and percent of empty stomachs: 22 (23.4%)

choice for Texas red drum and small blue crabs ranked second. He found shrimp dominant in all fish <460 mm. Yokel (1980) reported that red drum fed heavily on crustaceans throughout their range. Bass and Avault (1975) found that red drum <9 mm fed on copepods, and as length increased to 50 mm the diet shifted to Mysidacea. Boothby and Avault (1971) found little difference in food for various size groups with the principal difference being that smaller size fish fed on smaller prey species of fish, crabs, and shrimp.

The top 10 food items found in red drum stomachs are presented by season and sector in Table 83. Crustaceans were the primary food source and white shrimp were the most frequently occurring species for all seasons and sectors combined (Table 83). Crustaceans were the staple food source in the creeks with white shrimp and sand fiddler crabs as top items. In the sounds the preferred foods were mud and fiddler crabs although some fish fragments were observed. Although only two specimens were collected from the beaches, penaeid shrimp and Atlantic croaker were found in stomach contents.

During winter a wide variety of foods were ingested and there was high utilization of fish. The primary crustaceans consumed were grass and snapping shrimp as commercial penaeids were less abundant. The dominant fish species were mummichogs, menhaden and mullet. During spring they fed on both crabs and fish. During summer the main foods were white shrimp and fiddler and mud crabs, and during fall the major foods were mud crabs, white shrimp and fiddler crabs. Boothby and Avault (1971) found seasonal differences in feeding habits with fish more prevalent in diet during winter and spring while crustaceans became important during late spring.

Food availability and feeding activity appeared greatest in the creeks as 86.7% of the stomachs contained food (Table 84). In the sounds the percentage dropped slightly to 71.0%. Only two specimens were collected from the beaches and none were collected from offshore waters. Consequently, no conclusions are drawn for these sectors.

Seasonally, lowest feeding activity occurred during winter as only

Table 83. The 10 most frequently occurring food items found in the stomachs of red drum, *Sciaenops ocellatus*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Winter				Spring				Summer			
Sector	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	Stomachs	Percent Occurrence	Average % Bolus
Creeks	*Mugil cephalus*	1	100.0	90	Pisces	2	66.7	65	*Penaeus setiferus*	6	37.5	87
	Pisces	1	100.0	5	*Panopeus* sp.	1	33.3	90	Crustacea	3	18.8	37
					Crustacea	1	33.3	60	Organic material	3	18.8	17
									Callinectes sapidus	2	12.5	90
									Uca pugilator	2	12.5	90
									Palaemonetes sp.	2	12.5	20
									Crangon septemspinosa	1	6.3	90
									Panopeus sp.	1	6.3	80
									Penaeus aztecus	1	6.3	40
									Anthuridae	1	6.3	40
Sounds	*Palaemonetes* sp.	3	30.0	57	*Opsanus tau*	1	50.0	90	*Uca pugnax*	5	20.8	76
	Pisces	2	20.0	55	*Callinectes sapidus*	1	50.0	90	*Panopeus* sp.	5	20.8	36
	Alpheus sp.	2	20.0	15					*Uca pugilator*	4	16.7	50
	Eurypanopeus depressus	1	10.0	90					Organic material	3	12.5	63
	Fundulus heteroclitus	1	10.0	90					Pisces	3	12.5	43
	Brevoortia tyrannus	1	10.0	90					Natantia	3	12.5	37
	Syngnathidae	1	10.0	90					Crustacea	3	12.5	37
	Annelida	1	10.0	90					*Cyathura polita*	2	8.3	90
	Menidia menidia	1	10.0	80					Anthuridae	2	8.3	65
	Callinectes sapidus	1	10.0	60					*Penaeus setiferus*	2	8.3	55
Beaches	NONE[1/]	-	-	-	Pisces	1	100.0	100	*Micropogonias undulatus*	1	100.0	80
									Penaeidae	1	100.0	20
Offshore	NONE	-	-	-	NONE	-	-	-	NONE	-	-	-
Totals	*Palaemonetes* sp.	3	27.3	57	Pisces	3	50.0	73	*Penaeus setiferus*	8	19.5	79
	Pisces	3	27.3	37	*Panopeus* sp.	1	16.7	90	*Uca pugilator*	6	14.6	63
	Alpheus sp.	2	18.2	15	*Callinectes sapidus*	1	16.7	90	*Panopeus* sp.	6	14.6	43
	Fundulus heteroclitus	1	9.1	90	*Opsanus tau*	1	16.7	90	Plant material	6	14.6	40
	Brevoortia tyrannus	1	9.1	90	Crustacea	1	16.7	60	Crustacea	6	14.6	37
	Mugil cephalus	1	9.1	90					*Uca pugnax*	5	12.2	76
	Syngnathidae	1	9.1	90					Pisces	4	9.8	35
	Annelida	1	9.1	90					Anthuridae	3	7.3	57
	Menidia menidia	1	9.1	80					*Sesarma reticulatum*	3	7.3	43
	Callinectes sapidus	1	9.1	60					Decapoda	2	4.9	37

[1/] None denotes no specimens were collected with food in stomachs.

Table 83. (continued)

Sector	Fall: Food Item	Fall: No. Stomachs	Fall: Percent Occurrence	Fall: Average % Bolus	Combined Totals: Food Item	Combined Totals: No. Stomachs	Combined Totals: Percent Occurrence	Combined Totals: Average % Bolus
Creeks	*Uca pugilator*	3	50.0	90	*Penaeus setiferus*	8	30.8	88
	Penaeus setiferus	2	33.3	90	*Uca pugilator*	5	19.2	84
	Uca pugnax	2	33.3	65	Crustacea	4	15.4	43
	Sesarma reticulatum	1	16.7	10	Pisces	4	15.4	35
					Plant material	3	11.5	17
					Callinectes sapidus	2	7.7	90
					Panopeus sp.	2	7.7	85
					Uca pugnax	2	7.7	65
					Palaemonetes sp.	2	7.7	20
					Sesarma reticulatum	2	7.7	20
Sounds	*Panopeus* sp.	4	50.0	63	*Panopeus* sp.	9	20.5	48
	Pisces	2	25.0	15	Pisces	7	15.9	39
	Mugil cephalus	1	12.5	90	*Uca pugnax*	5	11.4	76
	Penaeus setiferus	1	12.5	90	*Uca pugilator*	5	11.4	42
	Portunus gibbesii	1	12.5	90	Decapoda	4	9.1	50
	Natantia	1	12.5	90	*Palaemonetes* sp.	4	9.1	48
	Callianassa atlantica	1	12.5	70	Crustacea	4	9.1	40
	Cyathura polita	1	12.5	30	*Cyathura polita*	3	6.8	70
					Penaeus setiferus	3	6.8	67
					Plant material	3	6.8	63
Beaches	NONE [1/]	-	-	-	Pisces	1	50.0	100
					Micropogonias undulatus	1	50.0	80
					Penaeidae	1	50.0	20
Offshore	NONE	-	-	-	NONE	-	-	-
Totals	*Panopeus* sp.	4	28.6	63	Pisces	12	16.7	42
	Peneaus setiferus	3	21.4	90	*Penaeus setiferus*	11	15.3	82
	Uca pugilator	3	21.4	80	*Panopeus* sp.	11	15.3	82
	Uca pugnax	2	14.3	65	*Uca pugilator*	10	13.9	63
	Pisces	2	14.3	15	Crustacea	8	11.1	41
	Mugil cephalus	1	7.1	90	*Uca pugnax*	7	9.7	73
	Portunus gibbesii	1	7.1	90	Plant material	6	8.3	40
	Decapoda	1	7.1	90	*Palaemonetes* sp.	6	8.3	38
	Callianassa atlantica	1	7.1	70	*Callinectes sapidus*	4	5.6	83
	Cyathura polita	1	7.1	30	Decapoda	4	5.6	50

[1/] None denotes no specimens were collected with food in stomachs.

Table 84. Number and percent of red drum, *Sciaenops ocellatus*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	1	50.0	1	50.0	2	100.0	10	66.7	5	33.3	15	100.0	-	-	-	-	-	-
Spring	3	100.0	0	0.0	3	100.0	2	100.0	0	0.0	2	100.0	1	100.0	0	0.0	1	100.0
Summer	16	84.2	3	15.8	19	100.0	24	66.7	12	33.3	36	100.0	1	100.0	0	0.0	1	100.0
Fall	6	100.0	0	0.0	6	100.0	8	88.9	1	11.1	9	100.0	-	-	-	-	-	-
Total	26	86.7	4	13.3	30	100.0	44	71.0	18	29.0	62	100.0	2	100.0	0	0.0	2	100.0

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	-	-	-	-	-	-	11	64.7	6	35.3	17	100.0
Spring	-	-	-	-	-	-	6	100.0	0	0.0	6	100.0
Summer	-	-	-	-	-	-	41	73.2	15	26.8	56	100.0
Fall	-	-	-	-	-	-	14	93.3	1	6.7	15	100.0
Total	-	-	-	-	-	-	72	76.6	22	23.4	94	100.0

64.7% of the stomachs contained food. Peak activity occurred during spring and fall with over 93% containing food (Table 84). At temperatures below 20°C only 67% contained food while at temperatures above 21°C the percentage jumped sharply to 80% (Table 50).

Feeding activity was greatest from last quarter through the three day period preceding new moon (Table 51). Lowest feeding activity took place during new moon when 50% of the stomachs examined were empty. Further discussion of feeding activity by lunar phase is precluded by limited sample size.

Crustaceans were the most common food item for red drum during all seasons. *Penaeus setiferus* was the most frequently occurring species during all seasons followed by a variety of other decapods such as *Panopeus herbstii* and *Uca pugilator* (Table 82). *P. setiferus* and *P. herbstii* were the 3rd and 11th most abundant crustaceans collected in three-meter trawl samples, respectively (Table 54). The most commonly occurring fish in red drum stomachs were *Fundulus heteroclitus*, *Brevoortia tyrannus*, and *Mugil cephalus*. Only *B. tyrannus* occurred in the top 15 most abundant fish species collected in the three-meter trawl samples. Although fish were a common food source, the data indicated that crustaceans were the preferred food items.

SOUTHERN FLOUNDER

Southern flounder (*Paralichthys lethostigma*) are geographically distributed in the Gulf of Mexico from Texas to south Florida and along the Atlantic coast from south Florida to North Carolina (Fischer, 1978).

Flounders prefer smooth mud and sand bottom areas conducive to burying beneath the sediment surface where they are concealed against predators while awaiting unwary prey. Flounders are often found feeding on crustaceans and juvenile fish during ebb tides at mouths of small tidal creeks. They are found at all depths within the estuaries but are quite common on shallow flats especially during flood tides.

Movement and Migration

From January 17, 1979 through June 28, 1982, 1,181 southern flounder were tagged and released. Length frequencies of tagged flounder in 50 mm length groups are included in Table 85. Lengths (TL) of specimens tagged with Howitt tags ranged from 118 to 629 mm while those tagged with Floy tags ranged from 145 to 451 mm. Length frequencies of flounder tagged with each tag type are shown in Table 86. Length frequencies of southern flounder collected for tagging are listed by 20 mm length groups and gear type in Table 87.

Tagged southern flounder were returned from March 21, 1979 through July 7, 1983. Of 1,181 flounder tagged, 75 (6.4%) were recaptured and tags returned. Recovery rates, when separated into 50 mm length groups, ranged as high as 7.9%. Recovery rates ranged from 4.3 to 7.9 percent for all 50 mm length groups between 151 and 500 mm (Table 85). Within this length range recovery rates indicated little difference in tag retention or fishing pressure as related to size of fish. The number of flounder released and recaptured, time at large, and distance traveled appear in Table 85. Time at large ranged from 2 to 716 days and averaged 215 days. Distance traveled ranged as far as 556 km with an average of 53.8 km. The overall recovery rate for southern flounder tagged with Howitt tags was 6.6% and with Floy tags it was 3.9% (Table 85).

Recreational fishermen were the major source of southern flounder recoveries with 41 (54.7%) of the 75 returns. Commercial fishermen returned 30 (40.0%) tags, while study activities accounted for the remaining 4 (5.3%) recoveries (Table 11). Of 41 recreational recaptures, 28 (68%) included sufficient information to determine lengths of creel size fish. Lengths (TL) of recreational recaptures ranged from 222 to 436 mm with an average size of 340 mm (Table 12). Length frequencies of recreational recoveries indicate that 96% of the fish ranged from 250 to 450 mm (Table 13).

Of the 75 recaptures, sufficient information was obtained on 69 (92%) fish to determine the location and season of recapture. The sounds had the highest return rate at 44.9% while the creeks had the

Table 85. Number tagged, number and percent recaptured, days at large and distance traveled for southern flounder, *Paralichthys lethostigma*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large		Distance Traveled (km)[1/]	
				Avg.	Max.	Avg.	Max.
101 - 150	2	0	0.0				
151 - 200	70	3	4.3	117	237	36.5	89
201 - 250	243	14	5.8	264	716	50.7	219
251 - 300	494	39	7.9	224	535	42.7	363
301 - 350	209	11	5.3	202	500	110.6	556
351 - 400	88	4	4.5	214	423	81.2	224
401 - 450	43	3	7.0	49	130	0.0	0
451 - 500	19	1	5.3	113	113	7.4	7
501 - 550	7	0	0.0				
551 - 600	3	0	0.0				
601 - 650	3	0	0.0				
Total	1,181	75	6.4	215	716	53.8	556

1/ Distance measured in kilometers from point of release to point of recapture.

Table 86. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for southern flounder, *Paralichthys lethostigma*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
125	1			1			2		
175	50	2	4.0	20	1	5.0	70	3	4.3
225	205	13	6.3	38	1	2.6	243	14	5.8
275	474	39	8.2	20			494	39	7.9
325	195	9	4.6	14	2	14.3	209	11	5.3
375	80	4	5.0	8			88	4	4.5
425	42	3	7.1	1			43	3	7.0
475	18	1	5.6	1			19	1	5.3
525	7						7		
575	3						3		
625	3						3		
Total	1,078	71	6.6	103	4	3.9	1,181	75	6.4

Table 87. Number of southern flounder *(Paralichthys lethostigma)*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Fish Length (mm)	Gill Net (stretch mesh:inches) 2	2 7/8	3 1/2	4 5/8	6	Trammel Net	Seine	Trawl	Cast Net	Trap	Hook and Line	Totals
110								1				1
130								0				0
150						1		7				8
170						0		12				12
190		2				2		47				51
210	1	3				3		60			1	68
230	1	4				15		77	1	2	0	100
250	0	20	1	2		11		135	0	2	2	173
270	1	10	1	0		11		172	2	2	1	200
290	1	13	0	1		10		170	0	1	0	196
310	0	13	0	1		7		90	0	1	1	113
330	1	10	1	0	1	10		51	0	0	1	75
350	0	10	1	0	0	3	1	24	0	1	2	42
370	0	5	0	1	0	5	1	26	0	0	1	39
390	1	4	1	1	0	8	0	11	1	1	0	28
410		9	2		2	3	0	5		0	0	21
430		7			2	2	0	6		0	1	18
450		3			2	2	1	1		1	1	11
470		2			1	3	0	3				9
490		3			0	0	0	0				3
510		2			0	1	1	1				5
530		2			0			0				2
550		0			1			1				2
570		0						0				0
590		0						1				1
610		1						1				2
630		1										1
TOTALS	6	124	7	6	9	97	4	902	4	11	11	1181

lowest at 10.1%. The percentage of flounders released in the creeks and sounds was proportionally higher than the percentage recaptured (Table 14). In contrast, the return rate from the beaches and offshore waters was proportionally higher than the release rate. Fishing pressure in offshore waters was primarily from commercial shrimp trawlers.

Of 69 flounder recoveries from which information was obtained, 56 (81%) were recaptured during summer and fall, with fall producing approximately half (50.7%) of all recoveries (Table 15). Winter produced the lowest return rate of only 2.9%.

Georgia residents fishing in state waters accounted for 27 (66%) of the 41 recreational recaptures. Of these resident fishermen, 22 (81%) traveled 40 km or less to reach the location of recapture and approximately 89% traveled less than 80 km (Table 16). In general, most flounder were caught incidentally while fishing for spotted seatrout.

The principal bait used by recreational fishermen to catch southern flounder was shrimp, with approximately 72% of all recoveries caught on live shrimp and 8.0% on dead shrimp (Table 17). Sixteen percent of the recoveries were caught on live minnows while artificial lures accounted for the remaining 4%. Avid flounder fishermen use primarily live mummichogs and small mullet as bait. Although most recoveries were caught on live shrimp, project personnel identified fish to be the preferred food item of this species (Table 97).

Approximately 19% of southern flounder recoveries were caught in the immediate area of release. Of 69 recoveries, 48 (69.6%) were recaptured within 25 km of the tagging site (Table 87). Other distances traveled and recovery rates were as follows: 25-100 km (13.1%); 101-300 km (13.1%); 301-500 km (2.9%); and over 500 km (1.4%) (Table 88). Although black drum exhibited the greatest individual distance traveled (619 km) for all species studied, southern flounder exhibited the greatest average distance at 53.8 km. Also, southern flounder exhibited the

Table 88. Days at large and distance traveled for southern flounder, *Paralichthys lethostigma*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Days At Large	Distance Traveled (km)										Total	Percent
	0	0.1-1	1-5	6-25	26-50	51-100	101-200	201-300	301-500	Over 500		
1 - 50	8	-	2	8	-	-	-	-	-	1	19	27.6
51 - 100	-	-	1	4	2	1	-	-	-	-	8	11.6
101 - 150	3	-	1	3	-	-	-	-	-	-	7	10.1
151 - 200	-	-	2	-	1	-	-	1	-	-	4	5.8
201 - 300	1	-	5	2	-	1	-	-	1	-	10	14.5
301 - 500	1	1	-	6	1	2	4	3	1	-	19	27.5
501 - 750	-	-	-	-	1	-	-	1	-	-	2	2.9
Total	13	1	11	23	5	4	4	5	2	1	69	100.0
Percent	18.9	1.4	15.9	33.3	7.3	5.8	5.8	7.3	2.9	1.4	100.0	

highest percentage (17.4%) of individuals traveling more than 100 km. Of the 15 specimens recaptured more than 50 km from the release site, 13 (87%) had moved southward an average distance of 176 km. Seven of these 13 were recaptured during spring and had traveled an average distance of 277 km. All southward recaptures were recovered during spring, summer, and fall. Only two recoveries traveled more than 50 km to the north. One recovered during the fall had traveled 89 km, and the other was recaptured during the spring near Surf City, North Carolina, after traveling 556 km. Recovery data indicated the greatest movement occurred during spring with an average distance of 202.2 km (Table 21).

Only 22 (32%) of all recoveries were caught within their estuary of release (Table 89). Recoveries within the estuary were during the summer and fall. The direction and season of greatest movement outside the estuary was southward during the fall, indicating movement to higher salinity areas and warmer waters.

Length-Weight Relationship

The length-weight relationship for southern flounder, based on 233 specimens ranging from 125 to 700 mm and 23 to 4,771 g., was as follows: $\log W = 3.091 \log L - 5.157$. The correlation coefficient value for length-weight for southern flounder was 0.9802 ($P < 0.0001$). Least-squares regression analyses on the length-weight relationships for male, female, and all southern flounder combined are shown in Table 24. Figure 27 illustrates the length-weight relationship for southern flounder.

Length-weight relationship calculated for Georgia southern flounder showed isometric growth ($b = 3.091$). The greatest lengths recorded for males and females were 362 and 700 mm, respectively. The heaviest specimens weighed 595 g for males and 4,771 g for females.

Age and Growth

Although several members of the genus *Paralichthys* have received extensive research in the northwest Atlantic, comparatively limited

Table 89. Seasonal movement of southern flounder, *Paralichthys lethostigma*, tagged in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

		Direction Moved By Recaptured Tagged Fish				
			Movement Within Estuary		Movement Out Of Estuary	
Season	Length Group (mm)	Caught In Area Of Release	Creek to Beach	Beach To Creek	North	South
Winter	151-200	-	-	-	-	-
	201-250	-	-	-	-	-
	251-300	-	-	-	-	1
	301-350	-	-	1	-	-
	401-450	-	-	-	-	-
	451-500	-	-	-	-	-
	Total	-	-	1	-	1
	Percent	-	-	50.0	-	50.0
Spring	151-200	-	-	-	1	-
	201-250	-	-	-	-	2
	251-300	-	-	-	1	4
	301-350	-	-	-	1	1
	351-400	-	-	-	1	-
	401-450	-	-	-	-	-
	451-500	-	-	-	-	-
	Total	-	-	-	4	7
	Percent	-	-	-	36.4	63.6
Summer	151-200	-	-	-	1	-
	201-250	-	-	-	-	1
	251-300	3	2	1	1	3
	301-350	3	1	-	-	3
	351-400	-	-	-	-	2
	401-450	-	-	-	-	-
	451-500	-	-	-	-	-
	Total	6	3	1	2	9
	Percent	28.6	14.3	4.8	9.5	42.8
Fall	151-200	-	-	-	1	-
	201-250	3	1	-	-	4
	251-300	1	2	-	2	13
	301-350	2	-	-	-	3
	351-400	1	-	-	-	1
	401-450	-	-	-	-	-
	451-500	-	1	-	-	-
	Total	7	4	-	3	21
	Percent	20.0	11.4	-	8.6	60.0
Combined	Total	13	7	2	9	38
	Percent	18.8	10.2	2.9	13.0	55.1

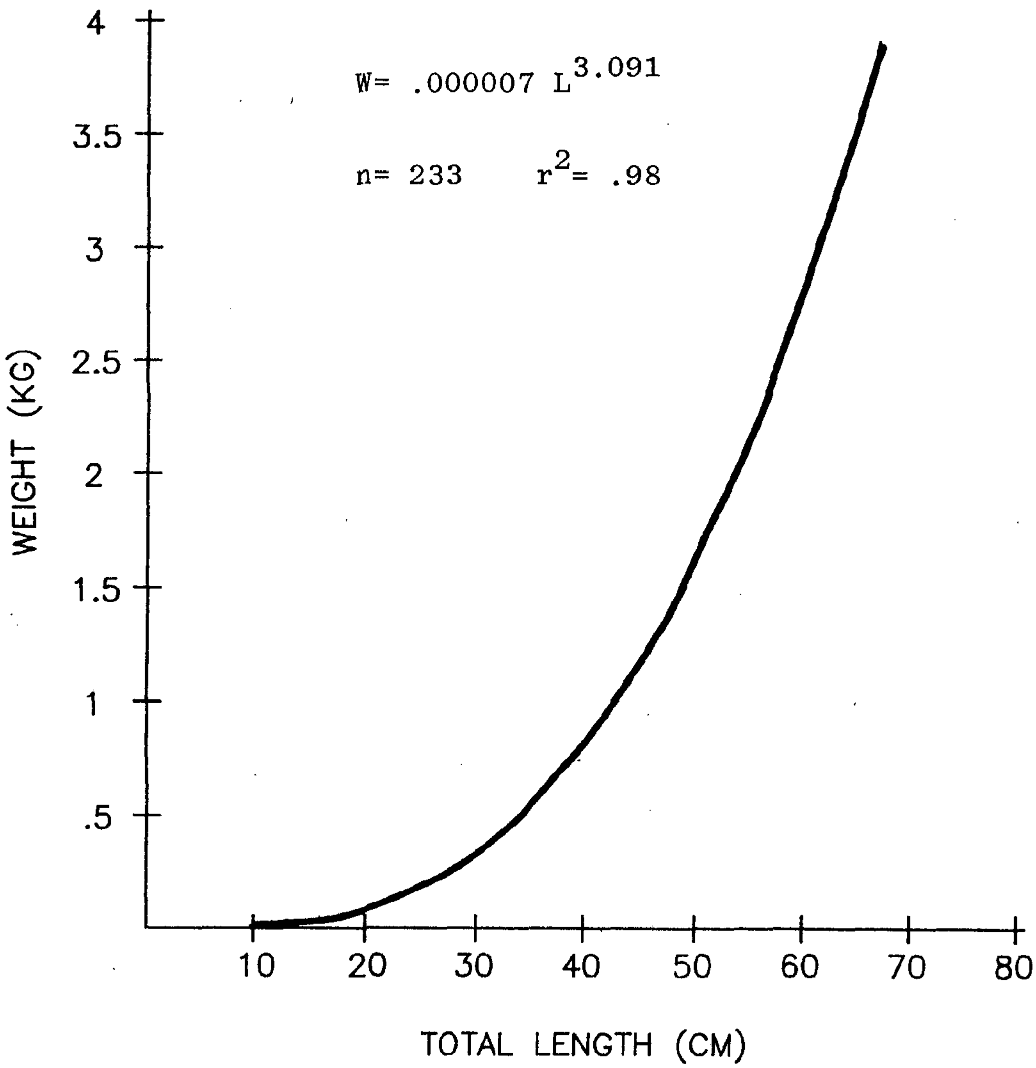

Figure 27. Length-weight relationship of southern flounder, *Paralichthys lethostigma*, collected in Glynn County, Georgia from January 1979 through June 1982.

work has been devoted to ageing southern flounder. Ageing techniques usually employed for southern flounder were length frequencies and otolith analyses (Stokes, 1977). Shepherd (1980) conducted a comparative study of various ageing methods for summer flounder including length frequencies, scales, otoliths, and dorsal fin rays and concluded "scales and fin rays are preferred because the annuli are usually more distinct." However, Shepherd added "...alternative methods using scales and fin rays will give comparable results to those obtained from otoliths." Therefore, we concluded scales and otoliths were reliable for ageing southern flounder.

Scales from 233 specimens ranging from 125 to 700 mm were examined, and 198 (85%) samples were considered legible for age determination. Otoliths from these 198 fish were also examined to document the validity of annuli counts made from scales. Annuli formation on scales of southern flounder appear as abrupt changes in the spacing of circuli patterns. As with many temperate fishes, rapid growth of young individuals often made the first annulus indistinct and difficult to detect. Year-mark counts on scales and otoliths from the same fish were found to be relatively consistent except during February, when otolith ring formation was frequently detected slightly earlier than the scale annulus.

The calculation of mean monthly growth of marginal increments validated that scale annuli were formed only once annually. A single annulus formation was detectable on southern flounder scales during February and March, with all scales bearing recent annuli by early April.

Linear regression analyses on the relationship between fish length and scale radius were performed. The r^2 value of 0.87 ($P < 0.0001$) suggests the relationship was sufficiently linear to warrant simple proportion calculations to determine fish length at time of annulus formation. The empirical and mean back-calculated total lengths at age for southern flounder are shown in Table 90. Figure 28 illustrates the length-age relationship for southern flounder, with the principle of least squares employed to draw the line of best fit. Length-age

Table 90. Mean back-calculated total lengths for southern flounder, *Paralichthys lethostigma*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

				Mean Back-Calculated Lengths of Successive Scale Rings					
Age	Number	Length Range at Capture	Mean Length at Capture	1	2	3	4	5	6
0	45	125 - 286	201						
1	103	155 - 382	276	167					
2	36	270 - 520	386	134	315				
3	9	362 - 588	496	144	312	431			
4	3	629 - 664	645	233	382	532	617		
5	1	622	622	131	289	425	503	589	
6	1	700	700	109	268	418	571	620	680
		Weighted Means		158	317	451	585	605	680
		Growth Increments		158	159	134	134	20	75

NOTE: Lengths measured in millimeters.

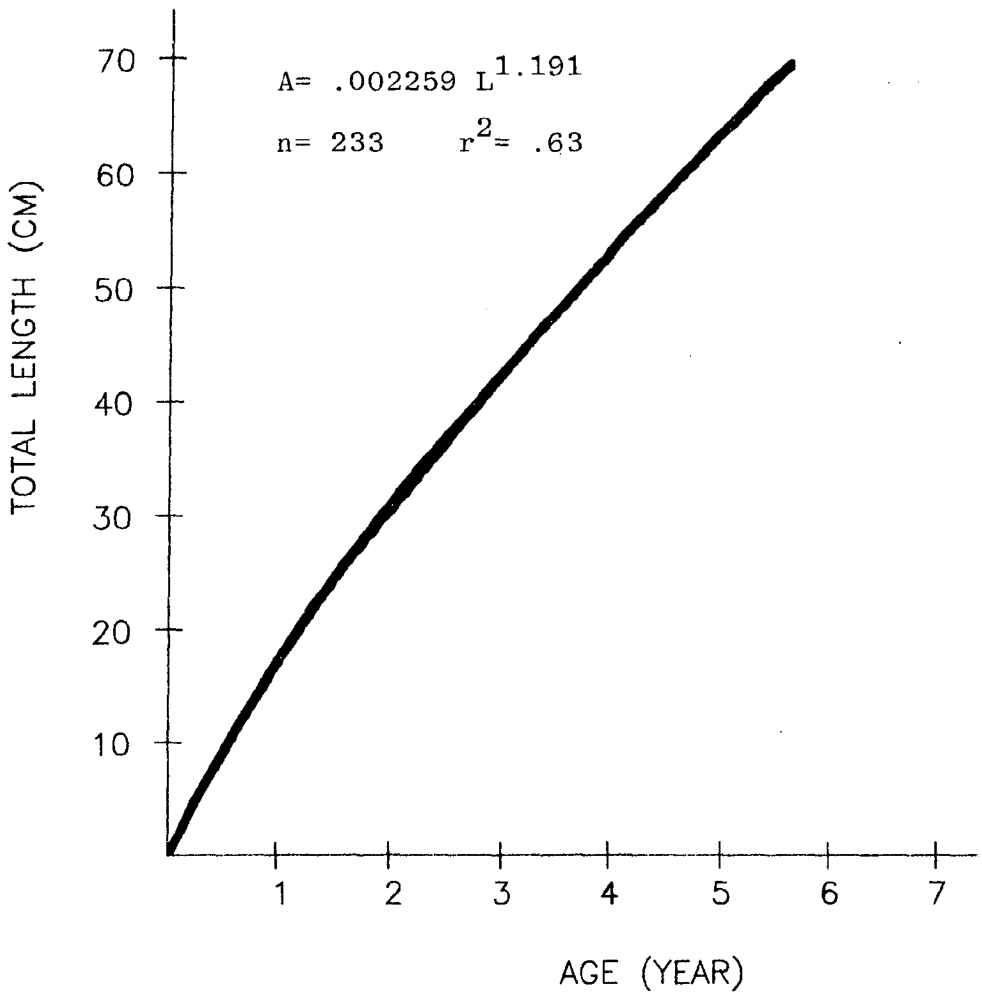

Figure 28. Length-age relationship of southern flounder, *Paralichthys lethostigma*, collected in Glynn County, Georgia.

equations appear in Table 27. Table 91 presents the empirical and weighted mean back-calculated lengths for juvenile, male, female, and combined southern flounder.

The annual growth rates determined from back-calculations were compared to the mean growth rates for nine southern flounder at large from 11 to 13 months. Their average length when tagged was 298 mm or approximately age II. Back-calculation data revealed the annual growth rate of flounder in their third year of life to be between 134 and 159 mm (Table 91). However, the annual growth estimate calculated from recapture data was approximately half the growth (73 mm) derived from back-calculations. Considering that growth rates based on back-calculations of Georgia fish were similar to rates reported for Texas flounders (Stokes 1977), it was assumed that tagging may have had a detrimental effect on the growth rate of this species.

The oldest southern flounder collected were an age III male and an age VI female. Stokes (1977) reported maximum ages of female and male Texas southern flounder to be IV and II, respectively. Lengths of Georgia and Texas flounder were comparable for fish of similar sex and age.

Maturity and Spawning

The southern flounder is the most common flounder in both commercial and recreational catches in Georgia waters. Little is known about spawning activity for this popular species because little, if any, spawning activity occurs in inshore waters. Mahood et al. (1974) found that young southern flounder were taken in Georgia throughout the year in seining operations with peak abundance during May.

The smallest southern flounder for which sex could be determined through gross examination were 130 mm (Age 0) for females and 232 mm (Age I) for males. Unfortunately, an insufficient number of adult specimens were collected to determine length and age at first spawning as spawning apparently takes place at sea outside our study area.

Table 91. Number, empirical and back-calculated total lengths, and growth increments by sex and age for southern flounder, *Paralichthys lethostigma*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Sex	Age 1	2	3	4	5	6
Juveniles						
Number	51	14				
Mean Length at Capture	256	332				
Back-Calculated Length	145	281				
Growth Increment	145	136				
Males						
Number	7	0	1			
Mean Length at Capture	260		362			
Back-Calculated Length	119	244	342			
Growth Increment	119	125	98			
Females						
Number	45	22	8	3	1	1
Mean Length at Capture	299	420	512	645	622	700
Back-Calculated Length	173	334	460	585	605	680
Growth Increment	173	161	126	125	20	75
Combined						
Number	103	36	9	3	1	1
Mean Length at Capture	276	386	496	645	622	700
Back-Calculated Length	158	317	451	585	605	680
Growth Increment	158	159	134	134	20	75

NOTE: Lengths measured in millimeters.

The sexes and maturity stages of 114 southern flounder examined during this study are presented in Table 92. All specimens old enough to determine sex exhibited early stages of gonadal development (stages I-III). Of all females examined, 92% were stage I, 7% were stage II, and only 1% (1 specimen) had reached stage III. Males showed even less development as 91% were stage I, 9% were stage II, and no stage III development was observed.

Maturity stages are presented by month and salinity in Table 93. The only stage III female observed was collected during August in waters with salinity in excess of 31 °/oo. This high salinity level is typical for Georgia beaches and offshore waters, and is probably an indicator that this fish was preparing to move offshore in anticipation of the fall and winter spawning season.

Maturity stages are presented by temperature and salinity in Table 94. Since no advanced stages of gonadal development were encountered in inshore waters, little can be surmised concerning maturity and spawning.

No larval or postlarval southern flounder were identified in ichthyoplankton samples. However, four unidentified postlarval specimens of the family Bothidae were collected in February (Table 63). Only one young southern flounder was collected in the 3-meter trawl, and this specimen was collected during the fall on the beach (Tables 52 and 53).

Ginsburg (1952) suggested that spawning probably takes place in late fall and early winter and that the season was probably extended. McClane (1965) reported that spawning apparently takes place in winter as ripening fish have been caught in October, and young fish one to two inches are taken from December to April off the Texas coast. Stokes (1977) reported that sex differentiation in Texas flounders became possible when fish were approximately 70 mm (6.7 in). He reported that this species progressed from stage 0 (no gonads present) to stage I (immature) to stage II (maturing) during the first year of life, and that adults in developing condition began to enter the catch

Table 92. Number of southern flounder, *Paralichthys lethostigma*, collected by month, sex and reproductive stage for the period January 1979 through June 1982.

	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
Month	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January														
February	2	0												
March	3	1												
April	5	0												
May														
June	12	0	1	0										
July	25	3	2	0										
August	21	0	1	0	1	0								
September	11	5	2	0										
October	8	0												
November			1	0										
December	7	1	0	1										

Table 93. Stages of gonadal development for southern flounder, *Paralichthys lethostigma*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Month	Reproductive Stage	Surface Water Salinity (0/00) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	36-40 F	36-40 M	Totals F	Totals M
January	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I	-	-	-	-	-	-	-	-	1	0	1	0	-	-	-	-	2	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I	-	-	-	-	-	-	2	1	1	0	-	-	-	-	-	-	3	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	-	-	-	-	1	0	-	-	-	-	2	0	2	0	-	-	5	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	I	-	-	-	-	-	-	-	-	4	0	7	0	1	0	-	-	12	0
	II	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
July	I	-	-	-	-	-	-	-	-	3	0	13	2	9	1	-	-	25	3
	II	-	-	-	-	-	-	-	-	-	-	-	-	2	0	-	-	2	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	I	-	-	-	-	-	-	-	-	10	0	7	0	4	0	-	-	21	0
	II	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	III	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I	-	-	-	-	2	0	5	5	1	0	3	0	-	-	-	-	11	5
	II	-	-	-	-	-	-	1	0	1	0	-	-	-	-	-	-	2	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I	-	-	-	-	-	-	1	0	3	0	2	0	2	0	-	-	8	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I	-	-	-	-	-	-	-	-	4	1	3	0	-	-	-	-	7	1
	II	-	-	-	-	-	-	-	-	0	1	-	-	-	-	-	-	0	1
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combined Totals	I	-	-	-	-	3	0	8	6	27	1	38	2	18	1	-	-	94	10
	II	-	-	-	-	-	-	1	0	2	1	2	0	2	0	-	-	7	1
	III	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 94. Stages of gonadal development for southern flounder, *Paralichthys lethostigma*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)	Reproductive Stage	Surface Water Temperature (°C) 0-5		6-10		11-15		16-20		21-25		26-30		31-35		Totals	
		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
6-10	I	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-15	I	-	-	-	-	-	-	-	-	1	0	2	0	-	-	3	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-20	I	-	-	-	-	-	-	2	1	1	0	5	5	-	-	8	6
	II	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-25	I	-	-	-	-	5	1	1	0	1	0	20	0	-	-	27	1
	II	-	-	-	-	0	1	-	-	-	-	2	0	-	-	2	1
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-30	I	-	-	4	0	-	-	-	-	3	0	20	2	11	0	38	2
	II	-	-	-	-	-	-	1	0	-	-	1	0	-	-	2	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-35	I	-	-	-	-	-	-	-	-	3	0	11	1	4	0	18	1
	II	-	-	-	-	-	-	-	-	-	-	1	0	1	0	2	0
	III	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	I	-	-	4	0	5	1	4	1	9	0	58	8	15	0	95	10
	II	-	-	-	-	0	1	1	0	-	-	5	0	1	0	7	1
	III	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

in mid-September. From October through December the adults showed stage IV (developed) and stage V (gravid) development. He further reported that they were gravid for the first time at two years. Laswell, Lyons and Bailey (1978) used carp pituitary hormone to induce spawning in southern flounder in the laboratory and found that the eggs hatched in 40 hr at 22°C water temperature.

More studies are needed on this species in Georgia as it was difficult to attain sufficient data on maturity and spawning from our sampling design and study area. Offshore work should be done with trawls during fall and winter to collect the large spawners.

Sex ratios favored females in all length groups with an overall ratio of 9.5:1 (Table 41). Males comprised 7% of the catch except in a salinity range of 16-20 °/oo where six (40%) of the 15 specimens were males (Table 93).

As shown in Table 40, southern flounder exhibiting advanced reproductive stages were virtually absent in collections made in Georgia estuaries, prohibiting the determination of fecundity for this species.

Food Preference and Feeding Habits

The food items ingested by southern flounder are presented by fish size in 100 mm length groups in Table 95. Of 221 stomachs examined, 113 (51.1%) contained food and 108 (48.9%) were empty (Table 96). Small specimens (<200 mm) consumed nearly equal proportions of fish and crustaceans. In specimens 201 to 400 mm, there was a sharp increase in the amount of fish being consumed with the bay anchovy (*Anchoa mitchilli*) and sea catfish (*Arius felis*) being dominant. The major crustaceans were white shrimp (*Penaeus setiferus*) and mantis shrimp (*Squilla empusa*). Specimens over 400 mm showed a definite preference for fish. Surprisingly, the dominant species ingested was sea catfish although menhaden (*Brevoortia tyrannus*) and mullet (*Mugil cephalus*) were also observed. The largest southern flounder collected for stomach analyses was a 700 mm specimen weighing 4.9 kg. This particular specimen had ingested a 292 mm (11.5 in) mullet.

Table 95. Stomach contents of southern flounder, *Paralichthys lethostigma*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group (mm) 101-200	201-300	301-400	401-500	501-600	601-700	Combined	Percent Occurrence	Average % Bolus
PISCES									
Pisces (unidentifiable)	4	27	22	4	1		58	51.3	56
Anchoa mitchilli		4	1				5	4.4	90
Arius felis		1	3	2	1		7	6.2	90
Brevoortia tyrannus			1	1	1		3	2.7	90
Elops saurus			1				1	0.9	70
Fundulus heteroclitus		1					1	0.9	90
Larimus fasciatus		1	1				2	1.8	40
Leiostomus xanthurus	1	1					2	1.8	90
Menticirrhus americanus		1					1	0.9	90
Mugil cephalus			1			1	2	1.8	90
Ophidion marginatum		1					1	0.9	90
Stellifer lanceolatus	1	1	1				3	2.7	30
Symphurus plagiusa	1						1	0.9	90
ARTHROPODA									
Crustacea (unidentifiable)	2	3					5	4.4	48
Callinectes sapidus		1	1				2	1.8	60
Decapoda	1	1	1				3	2.7	90
Neomysis americana	1						1	0.9	90
Ogyrides alphaerostris		1					1	0.9	60
Palaemonetes sp.	1	1					2	1.8	90
Penaeidae	1	1					2	1.8	70
Penaeus aztecus		1					1	0.9	90
Penaeus duorarum			1				1	0.9	90
Penaeus setiferus		2	3				5	4.4	90
Squilla empusa		3					3	2.7	90
Trachypeneus constrictus				1			1	0.9	90
CEPHALOPODA									
Cephalopoda (unidentifiable)			3				3	2.7	17
Lolliguncula brevis		1					1	0.9	90
ANNELIDA									
Nicolea simplex			1				1	0.9	10
INORGANIC MATERIAL	4	2					6	5.3	90

Number of Stomachs: 221
Number and percent of stomachs containing food: 113 (51.1%)
Number and percent of empty stomachs: 108 (48.9%)

Table 96. Number and percent of southern flounder, *Paralichthys lethostigma*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	2	50.0	2	50.0	4	100.0	8	40.0	12	60.0	20	100.0	-	-	-	-	-	-
Spring	9	75.0	3	25.0	12	100.0	5	50.0	5	50.0	10	100.0	-	-	-	-	-	-
Summer	17	65.4	9	34.6	26	100.0	45	48.4	48	51.6	93	100.0	7	77.8	2	22.2	9	100.0
Fall	8	42.1	11	57.9	19	100.0	10	41.7	14	58.3	24	100.0	2	50.0	2	50.0	4	100.0
Total	36	59.0	25	41.0	61	100.0	68	46.3	79	53.7	147	100.0	9	69.2	4	30.8	13	100.0

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	-	-	-	-	-	-	10	41.7	14	58.3	24	100.0
Spring	-	-	-	-	-	-	14	63.6	8	36.4	22	100.0
Summer	-	-	-	-	-	-	69	53.9	59	46.1	128	100.0
Fall	-	-	-	-	-	-	20	42.6	27	57.4	47	100.0
Total	-	-	-	-	-	-	113	51.1	108	48.9	221	100.0

Similar results have been reported by other investigators in other states. Stokes (1977) reported that 95% of the food found in small Texas southern flounder (10 mm to 150 mm) were invertebrates with mysids occurring most frequently. He reported that flounder in excess of 150 mm fed mainly on fish with 70% of the food items being fish. The most frequently occurring fish were anchovies, menhaden, croaker, and mullet. He reported penaeid shrimp as the most frequent invertebrate in fish over 150 mm. Powell and Schwartz (1979) reported that there were no major differences in the seasonal diet of flounders in Pamlico Sound, North Carolina, but reported that food consumption in juvenile flounders increased as temperature increased. Throughout the year mysids and fish were the principal food items. They also reported that older southern flounder fed almost solely on fish.

The southern flounder is a voracious top line predator and an excellent eating fish. However, it is probably grossly under exploited by recreational anglers in Georgia. Although coastal anglers often use mummichogs as bait for flounders, this particular prey species was identified in only one stomach. Most flounders are caught incidentally on live shrimp when anglers fish for spotted seatrout.

The 10 most common occurring food items found in southern flounder stomachs by season and sector appear in Table 97. Of all stomachs examined, sea catfish and bay anchovy were the dominant fishes ingested while white shrimp and mantis shrimp were the dominant crustaceans (Table 97).

Winter feeding activities were focused primarily on fish, with spot (*Leiostomus xanthurus*), blackcheek tonguefish (*Symphurus plaguisa*), and star drum (*Stellifer lanceolatus*) the primary species. Crustaceans ingested during winter included mysids and grass shrimp. In spring, only fish were found in stomachs, with bay anchovy, menhaden, mullet, star drum and ladyfish (*Elops saurus*) being ingested. During summer, fish were again the most frequently occurring food group with sea catfish and bay anchovy the dominant species. Summer feeding activities, however, showed much more diversity as a variety of crustaceans were also consumed, including white shrimp, mantis shrimp, and blue crabs

Table 97. The 10 most frequently occurring food items found in the stomachs of southern flounder, *Paralichthys lethostigma*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Sector	Winter Food Item	Winter No. Stomachs	Winter Percent Occurrence	Winter Average % Bolus	Spring Food Item	Spring No. Stomachs	Spring Percent Occurrence	Spring Average % Bolus	Summer Food Item	Summer No. Stomachs	Summer Percent Occurrence	Summer Average % Bolus
Creeks	*Leiostomus xanthurus*	1	50.0	100	Pisces	6	66.7	80	Pisces	11	64.7	40
	Mysidae	1	50.0	100	*Anchoa mitchilli*	2	22.2	100	Crustacea	4	23.5	38
					Brevoortia tyrannus	1	11.1	90	*Larimus fasciatus*	2	11.8	40
					Elops saurus	1	11.1	70	*Anchoa mitchilli*	1	5.9	90
									Palaemonetes sp.	1	5.9	90
									Fundulus heteroclitus	1	5.9	90
									Callinectes sapidus	1	5.9	50
									Penaeidae	1	5.9	50
									Cephalopoda	1	5.9	10
Sounds	Unidentified material	3	37.5	100	Pisces	2	40.0	100	Pisces	27	60.0	42
	Palaemonetes sp.	3	37.5	100	*Brevoortia tyrannus*	1	20.0	100	*Penaeus setiferus*	3	6.7	90
	Pisces	2	25.0	100	*Mugil cephalus*	1	20.0	100	*Squilla empusa*	3	6.7	90
	Symphurus plagiusa	1	12.5	100	*Stellifer lanceolatus*	1	20.0	100	Decapoda	3	6.7	90
	Stellifer lanceolatus	1	12.5	100					Cephalopoda	2	4.4	20
									Penaeus aztecus	1	2.2	90
									Penaeus duorarum	1	2.2	90
									Lolliguncula brevis	1	2.2	90
									Trachypeneus constrictus	1	2.2	90
									Arius felis	1	2.2	90
Beaches	NONE[1/]	-	-	-	NONE	-	-	-	*Arius felis*	5	71.4	100
									Anchoa mitchilli	1	14.3	100
									Brevoortia tyrannus	1	14.3	100
Offshore	NONE	-	-	-	NONE	-	-	-	NONE	-	-	-
Totals	Unidentified material	3	30.0	90	Pisces	8	57.1	83	Pisces	38	55.1	41
	Pisces	2	20.0	90	*Anchoa mitchilli*	2	14.3	90	*Arius felis*	6	8.7	90
	Leiostomus xanthurus	1	10.0	90	*Brevoortia tyrannus*	2	14.3	90	Crustacea	4	5.8	38
	Mysidae	1	10.0	90	*Mugil cephalus*	1	7.1	90	*Anchoa mitchilli*	3	4.3	90
	Symphurus plagiusa	1	10.0	90	*Stellifer lanceolatus*	1	7.1	90	*Penaeus setiferus*	3	4.3	90
	Stellifer lanceolatus	1	10.0	90	*Elops saurus*	1	7.1	70	*Squilla empusa*	3	4.3	90
	Palaemonetes sp.	1	10.0	90					Decapoda	3	4.3	90
									Cephalopoda	3	4.3	17
									Callinectes sapidus	2	2.9	60
									Larimus fasciatus	1	1.4	40

[1/] None denotes no specimens were collected with food in stomachs.

Table 97. (continued)

Sector	Fall: Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Combined Totals: Food Item	No. Stomachs	Percent Occurrence	Average % Bolus
Creeks	**Pisces**	3	37.5	100	**Pisces**	20	55.6	60
	Stellifer lanceolatus	1	12.5	100	**Crustacea**	4	11.1	38
	Ophidion marginatum	1	12.5	100	*Anchoa mitchilli*	3	8.3	90
	Penaeus setiferus	1	12.5	100	**Penaeidae**	2	5.6	70
	Penaeidae	1	12.5	100	*Larimus fasciatus*	2	5.6	40
	Unidentified material	1	12.5	100	*Leiostomus xanthurus*	1	2.8	90
					Penaeus setiferus	1	2.8	90
					Palaemonetes sp.	1	2.8	90
					Fundulus heteroclitus	1	2.8	90
					Stellifer lanceolatus	1	2.8	90
Sounds	**Pisces**	6	60.0	75	**Pisces**	37	54.4	52
	Leiostomus xanthurus	1	10.0	90	*Penaeus setiferus*	4	5.9	90
	Arius felis	1	10.0	90	**Decapoda**	3	4.4	92
	Mugil cephalus	1	10.0	90	*Squilla empusa*	3	4.4	90
	Penaeus setiferus	1	10.0	90	**Unidentified material**	3	4.4	90
	Ogyrides alphaerostris	1	10.0	60	*Arius felis*	2	2.9	90
	Inorganic material	1	10.0	40	*Mugil cephalus*	2	2.9	90
					Stellifer lanceolatus	2	2.9	90
					Inorganic materials	2	2.9	65
					Cephalopoda	2	2.9	20
Beaches	**Pisces**	1	50.0	100	*Arius felis*	5	55.6	90
	Crustacea	1	50.0	100	**Pisces**	1	11.1	90
					Anchoa mitchilli	1	11.1	90
					Brevoortia tyrannus	1	11.1	90
					Crustacea	1	11.1	90
Offshore	**NONE**[1/]	-	-	-	**NONE**	-	-	-
Totals	**Pisces**	10	50.0	81	**Pisces**	58	51.3	56
	Penaeus setiferus	2	10.0	90	*Arius felis*	7	6.2	90
	Leiostomus xanthurus	1	5.0	90	*Anchoa mitchilli*	5	4.4	90
	Arius felis	1	5.0	90	*Penaeus setiferus*	5	4.4	90
	Mugil cephalus	1	5.0	90	**Crustacea**	5	4.4	48
	Stellifer lanceolatus	1	5.0	90	**Unidentified material**	4	3.5	90
	Ophidion marginatum	1	5.0	90	*Brevoortia tyrannus*	3	2.7	90
	Crustacea	1	5.0	90	*Stellifer lanceolatus*	3	2.7	90
	Penaeidae	1	5.0	90	*Squilla empusa*	3	2.7	90
	Ogyrides alphaerostris	1	5.0	60	**Decapoda**	3	2.7	90

[1/] None denotes no specimens were collected with food in stomachs.

(*Callinectes sapidus*). Squid were also found in three stomachs during summer. Fall feeding habits also included a variety of organisms, but fish were again the preferred food item. There appeared to be no specific species preferred as food. White shrimp were the dominant crustacean although other species of crustaceans were found. Feeding activity was apparently greatest during spring when 63.6% of the stomachs contained food (Table 96). During fall and winter less than half of the stomachs examined contained food with 42.6% and 41.7%, respectively.

In the creeks, 59.0% of the stomachs contained food, but in the sounds the average dropped to 46.3%. Although only 13 stomachs were examined from the beaches, 69.2% contained food. No stomach samples were collected from offshore waters.

Feeding activity seemed to be greatest when water temperatures were between 16 and 25°C as 60% of the stomachs contained food (Table 50). At temperatures below 15°C only 41.5% contained food, and at temperatures above 26°C the figure was only 52%.

Feeding activity appeared greatest during the three day period following first quarter and during the three day period prior to new moon with 75% and 68.8% of the stomachs containing food, respectively (Table 51). Lowest feeding activity was observed during the three day period before and including full moon, and during new moon and the three day period thereafter as over 61.5% of the stomachs were empty.

As observed in Table 97, *Anchoa mitchilli* and *Arius felis* were the most frequently occurring fish in southern flounder stomachs while *Penaeus setiferus* and *Squilla empusa* were the major crustaceans. All four of these prey species were included in the top 15 most commonly occurring organisms collected with three-meter trawl (Table 54). All four of these organisms were bottom oriented and highly mobile. Therefore, considering the lay and wait feeding behavior of flounders, predation on these food items was probably greater than for less active or upper water column oriented species. In general, our data indicate southern flounder were opportunistic feeders, consuming any edible species passing within striking range.

SUMMER FLOUNDER

The geographical distribution of the summer flounder (*Paralichthys dentatus*) includes the Atlantic coast from Maine to Florida and the northeastern Gulf of Mexico (Dahlberg, 1976). Younger summer flounder, less than two years of age, prefer habitats similar to that of southern flounder. However, the occurrence of older summer flounder is relatively uncommon in Georgia estuaries. Apparently, the older individuals prefer the higher salinity areas of the offshore waters, but juveniles are abundant in the estuaries.

Movement and Migration

From March 22, 1979 through March 11, 1982, 141 summer flounder were tagged. Length frequencies of tagged flounder in 50 mm length groups are included in Table 98. Lengths (TL) of flounder tagged with Howitt tags ranged 159 to 342 mm while those tagged with Floy tags were 174 to 365 mm. Length frequencies of summer flounder tagged with each tag type are presented in Table 99. Table 100 lists the length frequencies of summer flounder collected for tagging in 20 mm groups by gear type.

Only one (0.7%) summer flounder was recaptured. This specimen was at large 167 days and traveled 19 km (Table 98). It was released in the sound and caught in offshore waters during May by a commercial shrimp trawler.

Length-Weight Relationship

The length-weight relationship for summer flounder, based on 25 specimens ranging from 89 to 258 mm and 7 to 168 g, was as follows: $\log W = 2.920 \log L - 4.807$. The correlation coefficient (r^2 value) for length-weight for summer flounder was 0.9899 ($P < 0.0001$). Figure 29 illustrates the length-weight relationship for summer flounder.

Age and Growth

In Georgia, juvenile summer flounder were the most abundant *Paralichthys* species taken during a recent trawl survey (Virginia Baisden, pers. comm.). However, summer flounder larger than 300 mm are relatively

Table 98. Number tagged, number and percent recaptured, days at large and distance traveled for summer flounder, *Paralichthys dentatus*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large		Distance Traveled (km) 1/	
				Avg.	Max.	Avg.	Max.
151 - 200	25	0	0.0				
201 - 250	75	1	1.3	126	126	18.7	19
251 - 300	34	0	0.0				
301 - 350	6	0	0.0				
351 - 400	1	0	0.0				
Total	141	1	0.7	126	126	18.7	19

1/ Distance measured in kilometers from point of release to point of recapture.

Table 99. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for summer flounder, *Paralichthys dentatus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
175	16			9			25		
225	54	1	1.9	21			75	1	1.3
275	28			6			34		
325	6						6		
375				1			1		
Total	104	1	1.0	37	0	0.0	141	1	0.7

Table 100. Number of summer flounder, *Paralichthys dentatus*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Gill Net (in) 1/ 2	Gill Net (in) 1/ 2-7/8	Trawl	Trap	Hook/Line	Totals
150	-	-	1	-	-	1
170	-	-	6	1	-	7
190	-	-	17	-	-	17
210	-	1	29	1	-	31
230	-	2	26	1	1	30
250	-	-	24	1	-	25
270	-	-	12	-	1	13
290	1	-	9	-	-	10
310	-	-	1	1	-	2
330	-	-	3	-	-	3
350	-	-	1	-	-	1
370	-	-	1	-	-	1
Totals	1	3	130	5	2	141

1/ Gill net sizes are stretch mesh measurements.

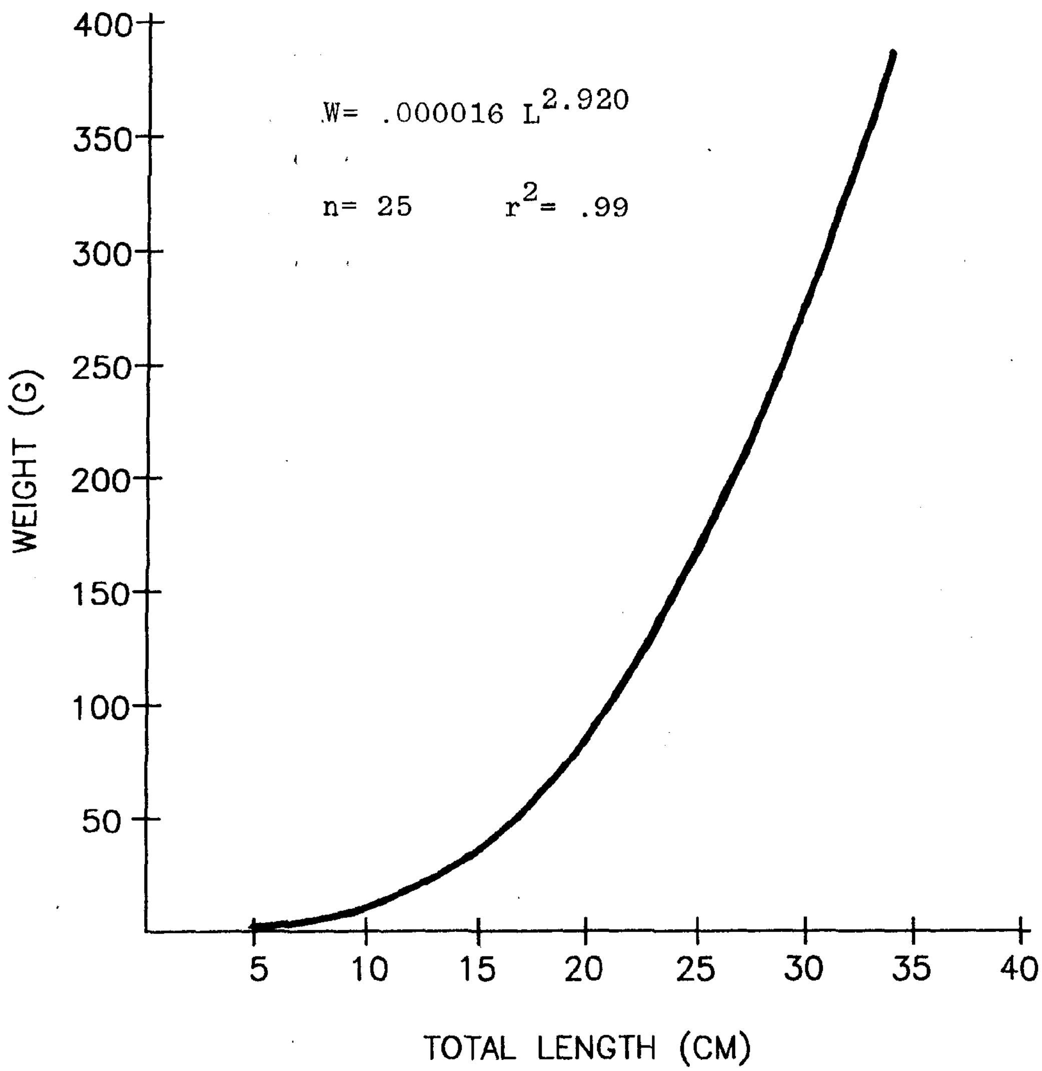

Figure 29. Length-weight relationship of summer flounder, *Paralichthys dentatus*, collected in Glynn County, Georgia from January 1979 through June 1982.

uncommon in Georgia's estuarine waters, making southern flounder the most common inshore flounder. Therefore, ageing of summer flounder was limited to young specimens.

Based on the findings of Poole (1961), Eldridge (1962), Powell (1974), Smith and Daiber (1977), and Shepherd (1980) as reported by Smith et al. (1981), mean total lengths of summer flounder at the time of first annulus ranged from 113 to 271 mm. Maximum ages for summer flounder ranged from age I for males and age III for females in Pamlico Sound, N.C. (Powell, 1974) to age VIII for males and IX for females from Hampton, Va. (Eldridge, 1962). The largest mean back-calculated length (691 mm) for summer flounder was reported for an age VII specimen from Martha's Vineyard Sound, Mass. (Shepherd, 1980).

Scales from 25 summer flounder ranging from 89 to 258 mm were examined and 23 (92%) were determined to be useable for age analyses. Of these 23 specimens, only one possessed an annulus (Table 101). The remainder were all in their first year of life. Insufficient numbers of fish bearing year marks prevented documentation of time of annulus formation and growth rate.

Maturity and Spawning

Of the 27 summer flounder collected, only three (11.1%) were adults and these were all young females exhibiting resting (stage I) ovarian development. These females were collected from salinity above 26 $^{o}/oo$ and temperatures above 26°C.

No young summer flounder were collected in the three-meter trawl during summer and fall, but one was found in winter and three were also collected in spring (Table 52). Three of these four specimens were collected in the creeks and one came from the sound (Table 53). Four postlarval specimens of the family Bothidae were identified in ichthyoplankton samples in February, but identification to the species level was not possible.

Juvenile summer flounder are often collected in inland waters,

Table 101. Mean back-calculated total lengths for summer flounder, *Paralichthys dentatus*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back-Calculated Lengths of Successive Scale Rings
				1
0	22	89 - 258	174	
1	1	207	207	143
		Weighted Mean		143
		Growth Increment		143

NOTE: Lengths measured in millimeters.

but as they increase in size, their abundance declines due to emigration from the estuaries. Mahood et al. (1974) reported that young summer flounder were taken during seining operations in Georgia from March through July, and were most abundant in May. Shipman, Baisden, and Ansley (1983) reported collecting summer flounder ranging from 13 to 335 mm with a mean length of 105 mm during a recent trawl study of juvenile marine species in Georgia. They found that summer flounder were most abundant during April and May, but none were collected during October and November.

Since summer flounder prefer sandy or hard bottoms (Hildebrand and Schroder, 1928; and Ginsburg, 1952), and since most of Georgia's estuarine areas consist of primarily soft mud and mud-sand substrates, it is highly probable that this is a major contributing factor for emigration of this species from the estuaries to offshore waters with increase in size. Adult summer flounder have been collected near the man-made reefs during April (personal observation) and have been reported by spear-fishermen during July.

Ginsburg (1952) reported that the spawning period for summer flounder was late fall and winter and possibly extended into spring in Chesapeake Bay, judging from available evidence presented by previous work by Hildebrand and Schroder (1928), and by Bigelow and Welsh (1925). Smith (1969) reported that summer flounder in Delaware Bay became sexually mature in their third year, but no ripe fish were taken in Delaware Bay. He reported signs of ripening gonads from August through November, and the smallest male with ripening testes was 30.5 cm long. Henderson (1979) reported spawning during the autumn migration to offshore wintering grounds (approximately 150 meters depth), and that the young spend their first year in bays or inshore areas in the northwest Atlantic. She also reported that maturity was reached at age three which agreed with the findings of Smith (1969).

Spawning periods for different areas range from late July through January in Narragansett Bay to December through April in North Carolina sounds (Henderson, 1979).

As shown in Table 40, the absence of advanced reproductive stages of summer flounder in Georgia estuaries prohibited determination of fecundity for this species.

Food Preference and Feeding Habits

In Georgia, summer flounder occur in relatively low numbers as compared to southern flounder. Although juveniles occur in trawl catches throughout the estuaries, larger specimens tend to move offshore. Hence, the larger specimens were not collected in sufficient quantities to make valid conclusions concerning feeding habits. Of 27 stomachs examined, 23 (85.2%) contained food and 4 (14.8%) were empty. The contents of stomachs containing food are presented by fish size in 100 mm groupings in Table 102. The most frequently occurring food item was mysid shrimp (26.1% occurrence) followed by grass shrimp, *Palaemonetes* sp., (17.3%), and unidentified decapod crustaceans (8.7%). In specimens <100 mm mysid shrimp and grass shrimp were identified although sample size was limited. In specimens 101-200 mm mysid shrimp and grass shrimp were dominant, but annelid worms and fish were also ingested. In specimens 201-300 mm fish, mysid shrimp and squid were ingested.

The 10 most frequently occurring food items by season and sector are presented in Table 103. The major food item during winter was mysid shrimp with a 30% occurrence rate. Other items included unidentified crustaceans and fish. In spring, mysid shrimp and grass shrimp were ingested, but only a limited sample was collected. In summer, unidentified fish occurred in 33.3% of the stomachs, but staple food items were crustaceans, primarily grass shrimp and the smaller penaeid shrimp (*Trachypeneus constrictus*). In fall, mysid shrimp dominated other items with 60% occurrence. In general, the major foods on a year round basis were mysid shrimp and grass shrimp although fish, squid and annelid worms were also consumed.

The major foods ingested in the creeks were fish, grass shrimp and mysid shrimp. In the sounds the major food was crustaceans, but fish

Table 102. Stomachs contents of summer flounder, *Paralichthys dentatus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group (mm) 1-100	101-200	201-300	Combined	Percent Occurrence	Average % Bolus
PISCES						
Pisces (Unidentifiable)		1	1	2	8.7	72
Anchoa mitchilli			1	1	4.3	90
ARTHROPODA						
Crustacea (Unidentifiable)		3		3	13.0	65
Decapoda		2		2	8.7	65
Mysidae	1	4	1	6	26.1	79
Palaemonetes sp.	1	3		4	17.3	90
Trachypeneus constrictus		1		1	4.3	40
CEPHALOPODA						
Lolliguncula brevis			1	1	4.3	90
ANNELIDA						
Nicolea simplex		1		1	4.3	10
PLANT						
Detritus		1		1	4.3	10
INORGANIC MATERIAL		1		1	4.3	90

Number of stomachs: 27

Number and percent of stomachs containing food: 23 (85.2%)

Number and percent of empty stomachs: 4 (14.8%)

Table 103. The 10 most frequently occurring food items found in the stomachs of summer flounder, *Paralichthys dentatus*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Winter				Spring				Summer			
Sector	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrance	Average % Bolus
Creeks	NONE	-	-	-	NONE	-	-	-	Pisces	1	50.0	100
									Palaemonetes sp.	1	50.0	100
Sounds	*Palaemonetes* sp.	3	33.3	90	*Palaemonetes* sp.	1	50.0	100	Pisces	1	100.0	100
	Crustacea	3	33.3	83	Mysidae	1	50.0	90				
	Unidentified material	1	11.1	90								
	Pisces	1	11.1	20					NONE	-	-	-
	Plant detritus	1	11.1	10								
Beaches	Pisces	1	100.0	100	NONE	-	-	-	*Trachypeneus constrictus*	1	33.3	45
									Decapoda	1	33.3	45
									Annelida	1	33.3	10
Offshore	NONE[1/]	-	-	-	NONE	-	-	-	NONE	-	-	-
Totals	*Palaemonetes* sp.	3	30.0	90	Mysidae	1	50.0	90	Pisces	2	33.3	45
	Crustacea	3	30.0	83	*Palaemonetes* sp.	1	50.0	90	*Palaemonetes* sp.	1	16.7	90
	Pisces	2	20.0	67					*Trachypeneus constrictus*	1	16.7	40
	Unidentified material	1	10.0	90					Decapoda	1	16.7	40
	Plant detritus	1	10.0	10					Annelida	1	16.6	10

1/ None denotes no specimens were collected with food in stomachs.

Table 103. (continued)

Sector	Fall				Combined Totals			
	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus
Creeks	Pisces	1	50.0	100	Pisces	2	50.0	90
	Mysidae	1	50.0	100	*Palaemonetes* sp.	1	25.0	90
					Mysidae	1	25.0	90
Sounds	Mysidae	5	62.5	74	Mysidae	6	30.0	77
	Anchoa mitchilli	1	12.5	90	*Palaemonetes* sp.	4	20.0	90
	Decapoda	1	12.5	90	Crustacea	3	15.0	65
	Lolliguncula brevis	1	12.5	90	Pisces	2	10.0	37
					Anchoa mitchilli	1	5.0	90
					Decapoda	1	5.0	90
					Lolliguncula brevis	1	5.0	90
					Unidentified material	1	5.0	90
					Plant detritus	1	5.0	90
Beaches	NONE[1/]	-	-	-	Pisces	1	25.0	90
					Trachypeneus constrictus	1	25.0	40
					Decapoda	1	25.0	40
					Annelida	1	25.0	10
Offshore	NONE	-	-	-	NONE	-	-	-
Total	Mysidae	6	60.0	77	Mysidae	7	25.9	72
	Pisces	1	10.0	90	*Palaemonetes* sp.	5	18.5	79
	Anchoa mitchilli	1	10.0	90	Pisces	5	18.5	90
	Decapoda	1	10.0	90	Crustacea	3	11.1	65
	Lolliguncula brevis	1	10.0	90	Decapoda	2	7.4	65
					Lolliguncula brevis	1	3.7	90
					Anchoa mitchilli	1	3.7	90
					Unidentified material	1	3.7	90
					Plant detritus	1	3.7	90
					Annelida	1	3.7	90

[1/] None denotes no specimens were collected with food in stomachs.

and squid were also ingested. On the beaches fish, crustaceans and annelid worms were important. Unfortunately, no specimens were collected from offshore waters.

The feeding habits of summer flounder have been reported by investigators in other areas. Ginsburg (1952) reported that summer flounder are primarily a predaceous fish, feeding chiefly on such species of fish and small invertebrates that are readily accessible in the region it inhabits. He reported that foods include mackerel, menhaden, tautog, sand launce, silversides, butterfish and scup, and invertebrates such as crabs, shrimp, squid, small mollusks and sand dollars. Smith (1969) found weakfish (*Cynoscion regalis*) to be the primary food for summer flounder in Delaware Bay. Smith and Daiber (1977) found that the percent occurrence for food items of summer flounder in Delaware Bay were "sand shrimp (*Crangon septemspinosa*, 41%), weakfish (*Cynoscion regalis*, 33%), mysid (*Neomysis americana*, 20%), anchovy (*Anchoa* sp., 7%), squid (*Loligo* sp., 4%), silversides (*Menidia menidia*, 1%), herring (*Alosa* sp., 1%), hermit crab (*Pagurus longicarpus*, 1%), and isopod (*Olencira praegustator*, 1%)". Fish under 450 mm fed predominantly on invertebrates while larger specimens ate more fish. They also suggested that the diet of summer flounder reflects local abundance of prey species. Powell and Schwartz (1979) reported no major seasonal differences in diet in young summer flounder, with mysids and fish being the principal food items. The rate of feeding in juvenile flounder decreased during winter, but increased as temperature increased. He reported that the diet of summer flounder consisted of shrimp and fish in similar quantities with increase in size while the diet of southern flounder consisted almost entirely of fish. Langton and Bowman (1981) reported the prey of eight summer flounder in the northwest Atlantic was primarily fish (47.8%) and squid (51.0%).

Feeding activity was high throughout the year as 85.2% of the stomachs contained food. Over 88.9% of the stomachs contained food during all seasons except spring at 60% (Table 104). However, too few specimens were collected for further discussion. Most specimens

Table 104. Number and percent of summer flounder, *Paralichthys dentatus*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	0	0.0	0	0.0	0	0.0	7	87.5	1	12.5	8	100.0	1	100.0	0	0.0	1	100.0
Spring	1	33.3	2	66.7	3	100.0	2	100.0	0	0.0	2	100.0	0	0.0	0	0.0	0	0.0
Summer	1	100.0	0	0.0	1	100.0	1	100.0	0	0.0	1	100.0	1	100.0	0	0.0	1	100.0
Fall	2	100.0	0	0.0	2	100.0	7	87.5	1	12.5	8	100.0	-	-	-	-	-	-
Total	4	66.7	2	33.3	6	100.0	17	89.5	2	10.5	19	100.0	2	100.0	0	0.0	2	100.0

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	-	-	-	-	-	-	8	88.9	1	11.1	9	100.0
Spring	-	-	-	-	-	-	3	60.0	2	40.0	5	100.0
Summer	-	-	-	-	-	-	3	100.0	0	0.0	3	100.0
Fall	-	-	-	-	-	-	9	90.0	1	10.0	10	100.0
Total	-	-	-	-	-	-	23	85.2	4	14.8	27	100.0

were collected in the sounds where 89.5% of the stomachs contained food. Again, too few specimens were collected from the other sectors to allow for analyses.

Water temperature apparently had little impact on feeding activity as over 75% of the stomachs contained food for all temperature ranges except 11-15°C when only two specimens were collected for a 50% food occurrence (Table 50).

No conclusions can be drawn for feeding activity as related to lunar activity as too few specimens were collected. The percentages of stomachs containing food versus empty stomachs are presented by lunar phase in Table 51.

BLACK DRUM

Black drum (*Pogonias cromis*) are found in the northern and eastern parts of the Gulf of Mexico, along the Atlantic coast from south Florida to the Gulf of Maine, around Cuba, most of the Antilles Islands, and along the Atlantic coast of South America from Guyana to Rio Grande, Brazil (Fischer, 1978).

Young black drum, less than four years of age, prefer areas near oyster reefs, piers, docks, jetties, bridges, and generally rough bottom areas where shellfish and crustaceans are plentiful. Larger specimens inhabit inshore sandy areas such as sounds, channels and surf zones.

Movement and Migration

From February 12, 1979 through May 7, 1982, 352 black drum were tagged and released. Length frequencies of tagged drum in 50 mm length groups are presented in Table 105. Lengths (TL) of drum tagged with Howitt tags ranged from 163 to 410 mm while those tagged with Floy tags ranged 150 to 414 mm. Length frequencies of drum tagged with each tag type are shown in Table 106. Of 352 tagged, 36 were tagged with both tag types to compare and evaluate tag retention. Table 107 lists the length frequencies of black drum collected for tagging in 20 mm groups by gear type.

Table 105. Number tagged, number and percent recaptured, days at large and distance traveled for black drum, *Pogonias cromis*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large Avg.	Days At Large Max.	Distance Traveled (km)[1/] Avg.	Distance Traveled (km)[1/] Max.
101 - 150	1	0	0.0				
151 - 200	37	5	13.5	226	359	4.8	24
201 - 250	165	28	17.0	173	529	29.3	445
251 - 300	66	27	40.9	126	424	18.2	165
301 - 350	62	26	41.9	100	321	77.5	619
351 - 400	17	5	29.4	138	455	88.4	217
401 - 450	4	1	25.0	331	331	0.0	0
Total	352	92	26.1	141	529	41.2	619

1/ Distance measured in kilometers from point of release to point of recapture.

NOTE: All recoveries did not possess date and location of recapture.

Table 106. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for black drum, *Pogonias cromis*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
125				1			1		
175	25	4	16.0	11			36	4	11.1
225	109	16	14.7	31	3	9.7	140	19	13.6
275	58	20	34.5	1			59	20	33.9
325	58	24	41.4	3			61	24	39.3
375	14	5	35.7	2			16	5	31.5
425	2			1			3		
Total	266	70	26.3	50	3	6.0	316	73	23.1

NOTE: Number tagged and recaptured does not include the 36 fish tagged with both tag types. Nineteen double tagged drum were recovered.

Table 107. Number of black drum, *Pogonias cromis*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Gill Net (in)[1/] 2	2-7/8	3-1/2	4-5/8	Trammel Net	Trawl	Cast Net	Trap	Hook/Line	Totals
150	-	-	-	-	-	-	-	1	-	1
170	-	1	-	-	-	1	-	3	1	6
190	-	17	-	-	4	4	1	4	1	31
210	-	48	1	-	13	-	1	5	16	84
230	2	21	-	-	10	-	-	5	12	50
250	2	14	3	-	8	-	-	4	15	46
270	-	10	-	-	3	-	1	1	15	30
290	-	4	-	-	1	-	3	-	13	21
310	-	7	1	-	-	-	2	-	20	30
330	-	4	-	-	1	-	-	-	18	23
350	-	4	-	-	-	-	-	1	11	16
370	-	4	-	-	-	-	-	-	4	8
390	-	1	-	-	-	-	-	-	1	2
410	-	-	-	1	-	-	-	-	3	4
Totals	4	135	5	1	40	5	8	24	130	352

[1/] Gill net sizes are stretch mesh measurements.

Tagged black drum were returned from June 23, 1979 through May 5, 1983. Of 352 drum tagged, 92 (26.1%) were recaptured and tags returned. Recovery rates, when separated into 50 mm length groups, ranged as high as 41.9%. Information on the number of fish released and recaptured, time at large, and distance traveled are shown in Table 105. Time at large ranged from 4 to 529 days with an average of 141 days. Distance traveled ranged as far as 619 km with an average of 41.2 km.

The recovery rate for drum tagged with Howitt tags was 25.2%, and with Floy tags it was 6.0% (Table 106). Recovery rates, when separated into 50 mm length groups, ranged as high as 41.4% with Howitt tags and 9.7% with Floy.

Of 36 drum tagged with both tag types, 19 (53%) were recovered. These individuals were at large from 12 to 310 days. Specimens possessing both tag types upon recapture were at large from 21 to 237 days with an average at large time of 164 days. Project personnel using hook and line gear recaptured two drum that had been single tagged with Floy tags, and only the monofilament line portion of the tag was left protruding from the fish. Thus, movement and growth information was lost on such recaptures. Increased recovery information would have been available if only Howitt tags had been employed. Furthermore, fishing pressure was obviously greater than was indicated by the observed recovery rate. Comparison of the number of returns by season of release indicated that drum released during the summer months probably had the highest survival rate (Table 10).

Recreational fishermen were the major source of black drum recoveries with 67 (72.8%) of the 92 returns. Only 2 (2.2%) returns were from commercial fishermen, while study activities accounted for the remaining 23 (25%) recoveries (Table 11). Of 67 recreational recaptures, 48 (72%) provided sufficient information to determine lengths of creel size fish. Lengths (TL) of recreational recaptures ranged from 225 to 461 mm with an average size of 341 mm (Table 12). Length frequencies of recaptures indicated most creel size drum ranged between 251 and 400 mm with the greatest number of recoveries (73%) occurring between 301 and 400 mm (Table 13).

The recovery rate versus the number of specimens released was greatest in the creeks at 63.0% (Table 14). The sounds produced 26.1% of the drum recoveries, the beach accounted for 10.9% and no recaptures were recorded from offshore waters. Return rates were highest during summer and fall (Table 15). Recovery rates for the sound were similar to creeks, but in summer the return rate in the sounds was significantly higher. Winter produced only 8 (8.7%) returns.

Georgia residents fishing in state waters accounted for 55 (82%) of the 67 recreational recoveries. Of these resident anglers, 49 (89%) traveled 40 km or less to reach the location of recapture. Approximately 96% of these fishermen traveled less than 80 km (Table 16).

The principal bait used by recreational fishermen to catch black drum was shrimp. Approximately 50.6% (40) of all drum recoveries were caught by recreational fishermen using dead shrimp with an additional 36.6% (29) taken on live shrimp (Table 17). Fiddler crabs produced seven (8.9%) returns with a minnow, mussel, and mole crab or "sand flea" accounting for the remaining three (3.9%).

Approximately 64% of black drum recoveries were caught in the immediate area of release. Of 92 recoveries, 77 (84%) were caught within 25 km of the tagging site, three (3.3%) moved 26 to 100 km, six (6.5%) moved 101 to 200 km, five (5.5%) traveled 301 to 500 km, and one (1.1%) traveled over 500 km (Table 108). Thirteen percent of all recaptures traveled over 100 km before recapture. Of 14 drum that traveled over 50 km from the release site, 12 had moved soutward, averaging 200 km. These southward moving recaptures were at large 20 to 442 days and recovered throughout the year with most recoveries occurring during summer and fall. The greatest southward movement (619 km) was by a 310 mm drum at large 185 days and recaptured in offshore waters near West Palm Beach, Florida. Only two drum traveled northward over 50 km, averaging 276 km. These northward migrants were at large from 128 to 455 days and recovered during November and January. Greatest northward movement (437 km) was from a 337 mm specimen at large 455 days and recaptured at the Murrells Inlet jetties, North Carolina. Recaptures indicated

Table 108. Days at large and distance traveled for black drum, *Pogonias cromis*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Days At Large	Distance Traveled (km)										Total	Percent
	0	0.1-1	1-5	6-25	26-50	51-100	101-200	201-300	301-500	Over 500		
1 - 50	18	1	-	1	-	-	3	1	-	-	24	26.1
51 - 100	5	-	1	4	-	-	-	-	1	-	11	11.9
101 - 150	17	-	1	3	1	1	1	1	1	-	26	28.3
151 - 200	7	-	-	3	-	-	-	-	-	1	11	11.9
201 - 300	7	-	1	1	-	-	1	-	-	-	10	10.9
301 - 500	5	1	-	1	-	1	1	-	1	-	10	10.9
Total	59	2	3	13	1	2	6	2	3	1	92	100.0
Percent	64.1	2.2	3.3	14.0	1.1	2.2	6.5	2.2	3.3	1.1	100.0	

that greatest movement was during winter with an average of 159.1 km. Spring and summer recoveries showed the least amount of movement (Table 21).

As shown in Table 109, movement in the estuary was limited with 64.1% of the black drum remaining in the general area of tagging. Movement within the estuary was generally toward outside waters as indicated by the number of returns that moved from a creek to beach direction. From the number of recaptures and distances traveled by fish emigrating from the estuary, drum apparently do not exhibit the same tendency to return to a specific estuary as was observed for spotted seatrout. For the most part, movement of drum out of the estuary was southward.

As stated earlier, one of the primary objectives for using Floy tags was for obtaining multiple recaptures to increase movement information. Unfortunately, only three black drum were recaptured a second time. Therefore, multiple recapture information was insufficient to ascertain movement trends. However, during April one black drum multiple recapture showed movement from the creek sector to the sound sector and back to the original release location within a 14 day period. Movement of the other two black drum indicated basically random movement within the estuary.

Length-Weight Relationship

The length-weight relationship for 79 black drum, ranging from 158 to 1,190 mm and 61 to 29,510 g, was $\log W = 3.075 \log L - 4.969$. The correlation coefficient value for length-weight was 0.9902 ($P < 0.0001$). Least-squares regression analyses on the length-weight relationships for male, female, and all black drum combined are shown in Table 24. Figure 30 illustrates length-weight relationship for black drum.

Length-weight relationships calculated for black drum showed isometric growth ($b = 3.075$). Greatest lengths recorded were 492 mm for males and 1,190 mm for females. The heaviest male weighed 1,885 g, and the heaviest female was 29,510 g. However, sex was not determined for

Table 109. Seasonal movement of black drum, *Pogonias cromis*, tagged in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

		Direction Moved By Recaptured Tagged Fish				
		Caught In Area	Movement Within Estuary		Movement Out Of Estuary	
Season	Length Group (mm)	Of Release	Creek to Beach	Beach To Creek	North	South
Winter	151-200	-	-	-	-	-
	201-250	2	-	-	-	1
	251-300	2	-	-	-	1
	301-350	-	-	-	-	1
	351-400	-	-	-	-	1
	401-450	-	-	-	-	-
	Total	4	-	-	-	4
	Percent	50.0	-	-	-	50.0
Spring	151-200	1	-	-	-	-
	201-250	6	1	-	-	1
	251-300	3	1	-	-	1
	301-350	-	-	-	-	1
	351-400	-	-	-	-	-
	401-450	-	-	-	-	-
	Total	10	2	-	-	3
	Percent	66.7	13.3	-	-	20.0
Summer	151-200	3	-	-	-	1
	201-250	11	2	-	-	1
	251-300	5	1	-	1	-
	301-350	5	2	-	1	2
	351-400	-	-	-	-	1
	401-450	-	-	-	-	-
	Total	24	5	-	2	5
	Percent	66.7	13.9	-	5.5	13.9
Fall	151-200	4	-	-	-	1
	201-250	4	-	-	-	1
	251-300	5	1	-	-	3
	301-350	6	-	-	2	2
	351-400	2	-	-	-	1
	401-450	-	-	-	-	1
	Total	21	1	-	2	9
	Percent	63.6	3.0	-	6.1	27.3
Combined	Total	59	8	-	4	21
	Percent	64.1	8.7	-	4.4	22.8

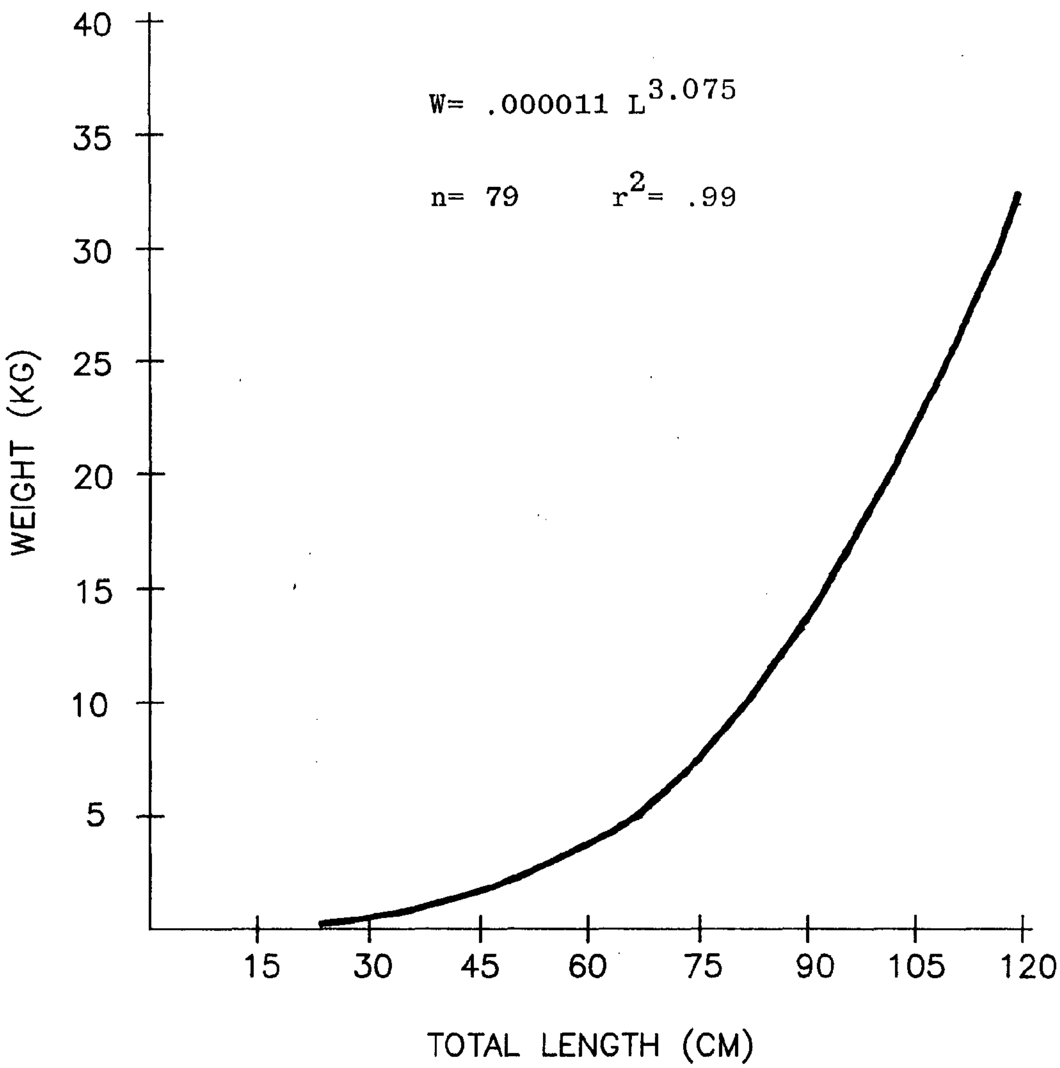

Figure 30. Length-weight relationship of black drum, *Pogonias cromis*, collected in Glynn County, Georgia from January 1979 through June 1982.

one specimen measuring 1,207 mm and 36,774 g. This fish was entered in the state's saltwater fishing records program. The weights of Georgia drum are compared with fish from other areas in Table 110. In general, Georgia drum were heavier at length than reported for fish from Delaware (Thomas, 1971), Texas (Marcello and Strawn, 1972), Virginia (Richards, 1973), and Louisiana (Hein, Dugas, and Shepard, 1980).

Age and Growth

Age and growth studies based on length frequencies of black drum have been conducted by Pearson (1929), Simmons and Breuer (1962), and Richards (1973). Pearson (1929) and Richards (1973) also investigated the use of scales for ageing black drum. In general, length frequencies were useful only for the first several years of life, and alternative ageing methods must often be employed for older fish.

Difficulty in ageing black drum occurred when attempting to age individuals older than four or five years of age. The difficulties were compounded by increased calcification or thickening of the scales, narrowing of increments, and formation of more than one annulus-like mark per year in older fish. According to Richards (1973), the formation of two rings per year probably does not begin precisely in the fourth year, but may occur earlier with some individuals.

Scales and otolith sections from 86 black drum ranging from 158 to 1,207 mm were examined, and scales from 76 (88%) were considered legible for age determinations. Of these 76 specimens, 72 (95%) were less than 493 mm in length. Scales and otoliths proved useful for individuals less than 500 mm, but disconformities made scales impossible to read and thus unreliable as an ageing structure for larger specimens.

Calculation of mean monthly growth from marginal increments indicated that scale annuli of young black drum form during February, March, and April. However, insufficient collections of older drum prevented the validation of time of ring formation or number of rings formed per year. In an effort to validate the number of annuli being laid down each year, scale samples from five recaptured black drum were compared with samples taken at the time of release. Unfortunately,

Table 110. Comparison of total length-weight relationships for several populations of black drum, *Pogonias cromis*.

Study	Location	Length - Weight Equation	Weight of Fish (g)		
			350 mm	500 mm	750 mm
Thomas (1971)	Delaware	$\log W = 3.241 \log L - 5.323$ [1/]	425	1,348	5,004
Marcello and Strawn (1972)	Texas	$\log W = 3.165 \log L - 4.981$ [2/]	612		
Richards (1973)	Virginia	$\log W = 3.066 \log L - 4.909$ [3/]	667	1,990	6,900
Hein, Dugas, and Shepard (1980)	Louisiana	$\log W = 2.971 \log L - 4.818$	550	1,587	5,292
Present Study	Georgia	$\log W = 3.075 \log L - 4.969$	712	2,132	7,416

[1/] Equation based on standard length (mm).

[2/] Equation based on standard length of specimens less than 301 mm.

[3/] Equation based on total length (cm) and total weight (kg).

NOTE: Standard lengths converted to total lengths using the formula TL = 1.23 SL.

maximum time at large for these fish was 126 days and none of these possessed additional annuli.

Linear regression analyses of the relationship between fish length and scale radius were performed. The r^2 value of 0.93 ($P < 0.0001$) suggests the relationship was sufficiently linear to warrant the application of direct proportion calculations to determine length at time of annulus formation. The empirical and mean back-calculated lengths at age for black drum are shown in Table 111. Table 112 shows the empirical and weighted mean back-calculated lengths for juvenile, male, female, and combined black drum. Figure 31 illustrates the length-age relationship for sexes combined, and Table 29 presents the length-age equations for young black drum.

Based on length frequency data, Pearson (1929) reported a modal-length of approximately 250 mm by the end of the first year and 370 mm by the end of the second year for Texas black drum. Simmons and Breuer (1962) reported that a standard length of 140-180 mm (167-214 mm TL)[1/] was reached in one year and 290-330 mm (345-393 mm TL) for two year old Texas drum. Richards (1973) back-calculated the lengths of 272 Virginia drum and determined mean lengths to be 195, 396, 554, and 669 mm for the first four scale rings, respectively. Georgia drum of similar age exhibited mean lengths of 198, 336, 440, and 538 mm, respectively. Unfortunately, at-large time for black drum recaptures was not sufficient to document and validate growth rate. Only one tagged drum was at large for approximately one year (352 days). This fish measured 195 mm when tagged and grew to 380 mm, a growth increase of 185 mm. In general, the lengths of black drum reported from Texas and Virginia were similar to those for Georgia. However, black drum from Virginia waters appear to attain greater lengths for each successive scale ring.

Determination of age using the scale technique became increasingly more difficult and unreliable for drum larger than 500 mm. Table 113 lists the lengths and otolith ring counts of all black drum over 400 mm.

[1/] Converted from standard length to total length using the conversion equation TL = 1.1956.

Table 111. Mean back-calculated total lengths for black drum, *Pogonias cromis*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Ring Class	Number	Length Range at Capture	Mean Length at Capture	Mean Back-Calculated Lengths of Successive Scale Rings													
				1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	37	158 - 270	212														
1	24	205 - 424	287	213													
2	6	343 - 461	393	172	345												
3	1	447	447	220	366	445											
4	3	464 - 582	513	153	311	422	506										
6	1	733	733	178	327	508	601	659	723								
14	2	893 - 918	905	170	337	430	554	608	632	666	716	763	809	832	859	883	900
		Weighed Means		198	336	440	538	625	662	666	716	763	809	832	859	883	900
		Growth Increments		198	138	104	98	87	37	4	50	47	46	23	27	24	17

NOTE: Lengths measured in millimeters.

Table 112. Number, empirical and back-calculated total lengths, and growth increments by sex and age for black drum, *Pogonias cromis*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Sex	Scale Ring Class 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Juveniles														
Number	9	2												
Mean Length at Capture	305	379												
Back-Calculated Length	219	346												
Growth Increment	219	127												
Males														
Number	10	2	1	1										
Mean Length at Capture	274	402	447	492										
Back-Calculated Length	188	332	423	490										
Growth Increment	188	144	91	67										
Females														
Number	5	2	0	2	0	1	0	0	0	0	0	0	0	2
Mean Length at Capture	282	397		523		733								905
Back-Calculated Length	192	340	455	547	625	662	666	716	763	809	832	859	883	900
Growth Increment	192	148	115	92	78	37	4	50	47	46	23	27	24	17
Combined														
Number	24	6	1	3	0	1	0	0	0	0	0	0	0	2
Mean Length at Capture	287	393	447	513		733								905
Back-Calculated Length	198	336	440	538	625	662	666	716	763	809	832	859	883	900
Growth Increment	198	138	104	98	87	37	4	50	47	46	23	27	24	17

NOTE: Lengths measured in millimeters.

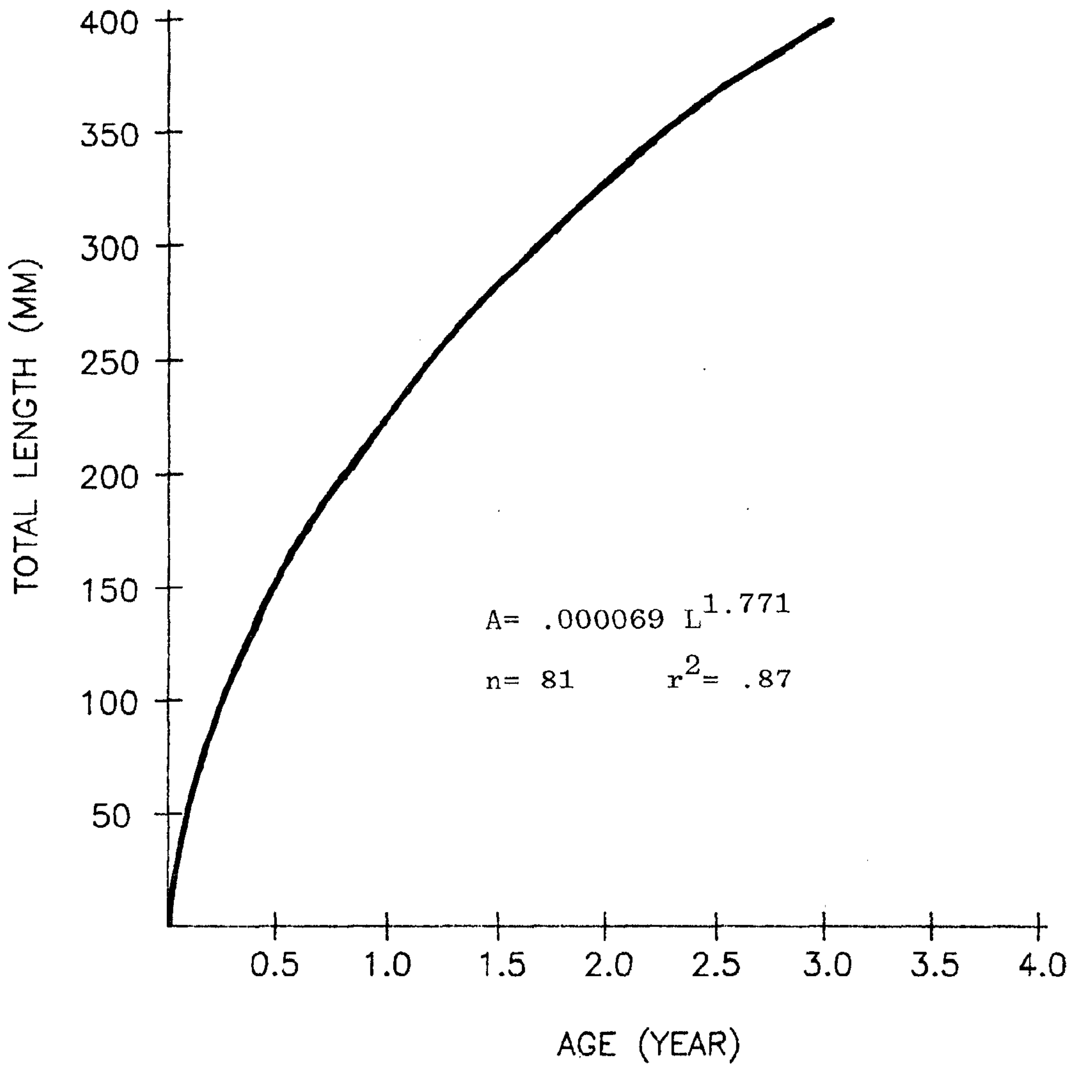

Figure 31. Length-age relationship of black drum, *Pogonias cromis*, collected in Glynn County, Georgia.

Table 113. Total lengths and number of otolith rings for all black drum greater than 400 mm.

Total Length (mm)	Number of Otolith Rings	Total Length (mm)	Number of Otolith Rings
420	2	893	14
424	2	918	14
425	2	947	12
447	3	1,124	44
461	2	1,132	46
464	4	1,146	43
492	4	1,183	30
560	3	1,190	37
582	4	1,207	34
733	6		

As stated earlier, Richards (1973) reported that two rings are probably formed each year after the fourth year. Based on his findings, a drum exhibiting 46 otolith rings would be approximately 25 years old. However, Rohr (1980) reported the additional rings on red drum otoliths may consist of summer and winter annuli and spawning checks. Such findings could possibly be applicable to black drum. If three rings are formed each year after maturity, the 1,132 mm drum would be approximately 18 years old. However, it should be noted that several investigations using various methods, including the uranium decay series nuclides ^{226}Ra and ^{210}Pb to establish the periodic nature of growth-zones in otoliths, have estimated the maximum age of some species of the genus *Sebastes* to be 80 to 140 years (Bennett, Boehlert and Turekian, 1982; Chitton and Beamish, 1982). Although the number of otolith rings that black drum form annually are questionable, it is not totally unreasonable for drum to reach 46 years of age. In general, the first 4 to 5 scale and otolith ring classes were considered reliable for estimation of age (Table 112). However, greater ring classes were not reliable and until the number of rings formed annually by older drum can be documented, only estimations of age can be made (Figure 32). Further investigation should be conducted in this area.

Maturity and Spawning

During this study the smallest specimens collected for which sex was determined through gross examination was a 200 mm (age 0) female and a 187 mm (age 0) male. The smallest female exhibiting developing ovaries was a 582 mm (age IV) specimen. No males exhibiting advanced development were collected, but one stage II specimen 947 mm in length was observed. It is expected that much smaller reproductive males probably occur, but we failed to collect them. Once drum are sexually mature they are reported to spawn annually until death (Pearson, 1929). In south Carolina they have been reported to reach sexual maturity at the end of their second year at a length of 14-16 inches with spawning from February through May in offshore waters and at inlets to sounds

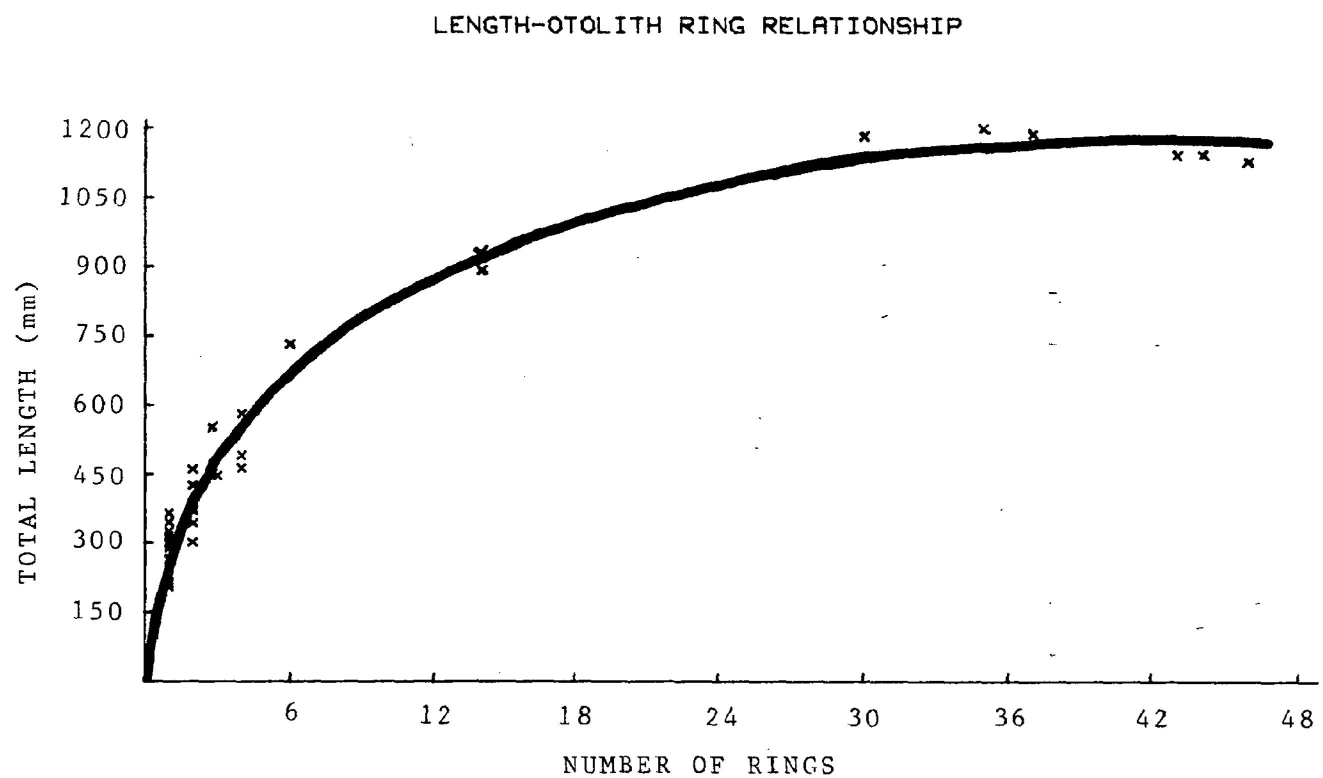

Figure 32. Empirical length/otolith ring relationship for black drum, *Pogonias cromis*, collected in Glynn County, Georgia.

and rivers (Lunz, 1955). Frisbie (1961) reported spawning in offshore waters of mid-Atlantic from March to May in the Chesapeake Bay and Delaware Bay at the northern limits of the effective spawning range. Simmons and Breuer (1962) reported spawning in all the bays and over any type bottom as well as in the Gulf near passes. They reported that spawning takes place in February and March, but there is a prolonged or split season in May or June. Richards (1973) reported that the adults concentrate in Virginia waters during spring and early summer for spawning. Ripe adults were encountered from April through mid-June and then the adults apparently dispersed throughout Chesapeake Bay after spawning. Silverman (1979) reported that black drum became sexually mature by the end of the second year when approximately 285-330 mm, and that spawning takes place primarily in ocean waters and in bays with peak spawning during May. Ross, Ravela and Chittenden (1983) suggested offshore spawning in the Gulf due to the occurrence of well developed gonads in March and April.

Most of the black drum collected during this study were under age II -- the age at which maturity is reached (Lunz, 1955; Silverman, 1979). The maturity stages of the 43 drum for which sex was determined are presented by month, sex, and reproductive stage in Table 114. Spawning apparently took place primarily during March and April as advanced maturity was encountered only during these months. However, spawning activity probably took place from March through May even though large specimens in spawning condition were not collected.

Females exhibiting advanced ovarian development were collected in April and May in salinities ranging from 21 to 25 $^{o}/oo$, and spent females were taken in May from salinities >26 $^{o}/oo$ (Table 115). Advanced "prespawn" and ripe females were collected at temperatures ranging from 16 to 25^{o}C, but at temperatures above 26^{o}C, only spent females were found (Table 116).

Although only four advanced maturity stages were collected, spawning activities appeared to be centered around full moon as the two prespawners (stage V and VI) were collected during the three day period

Table 114. Number of black drum, *Pogonias cromis*, collected by month, sex and reproduction stage for the period January 1979 through June 1982.

Month	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	2	6												
February	0	3												
March	2	13												
April	3	1	0	1							1	0		
May	2	1							1	0			2	0
June	0	1												
July														
August	1	0												
September	1	1												
October														
November	0	1												
December														

Table 115. Stages of gonadal development for black drum, *Pogonias cromis*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Month	Reproductive Stage	Surface Water Salinity (0/00) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	36-40 F	36-40 M	Totals F	Totals M
January	I	-	-	-	-	-	-	1	5	1	0	0	1	-	-	-	-	2	6
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I	-	-	-	-	-	-	0	2	-	-	0	1	-	-	-	-	0	3
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I	-	-	1	8	0	2	-	-	0	1	-	-	1	2	-	-	2	13
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	-	-	-	-	-	-	-	-	1	1	-	-	2	0	-	-	3	1
	II	-	-	0	1	-	-	-	-	-	-	-	-	-	-	-	-	0	1
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VI	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	I	-	-	-	-	-	-	1	0	1	0	0	1	-	-	-	-	2	1
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
June	I	-	-	-	-	-	-	-	-	0	1	-	-	-	-	-	-	0	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
July	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	I	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I	-	-	-	-	-	-	-	-	-	-	0	1	-	-	-	-	0	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combined Total	I	-	-	1	8	0	2	2	7	4	3	1	5	3	2	-	-	11	27
	II	-	-	0	1	-	-	-	-	-	-	-	-	-	-	-	-	0	1
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	VI	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	VII	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0

Table 116. Stages of gonadal development for black drum, *Pogonias cromis*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)	Reproductive Stage	Surface Water Temperature (^{o}C) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	Totals F	Totals M
0-5	I	-	-	-	-	-	-	0	1	-	-	-	-	-	-	0	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-10	I	-	-	-	-	1	8	-	-	-	-	-	-	-	-	1	8
	II	-	-	-	-	-	-	0	1	-	-	-	-	-	-	0	1
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-15	I	-	-	-	-	-	-	0	2	-	-	-	-	-	-	0	2
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-20	I	-	-	1	7	-	-	-	-	1	0	-	-	-	-	2	7
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-25	I	-	-	-	-	1	0	1	2	1	0	1	1	-	-	4	3
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	VI	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-30	I	-	-	0	1	0	1	-	-	0	1	1	1	-	-	1	4
	II-VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	2	0	-	-	2	0
31-35	I	-	-	-	-	-	-	-	-	3	2	-	-	-	-	3	2
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	I	-	-	1	8	2	9	1	5	5	3	2	2	-	-	11	27
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	VI	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	VII	-	-	-	-	-	-	-	-	-	-	2	0	-	-	2	0

prior to full moon, whereas the two spent females were collected three days prior to new moon (Table 40).

The overall ratio of females to males was 1:1.5 (Table 41). Males outnumbered females in the smaller specimens. However, for specimens 251-500 mm the sex ratio was equal, and in specimens over 500 mm no males were collected. The number and percent of females versus males by salinity gradient are presented in Table 39. No distinct segregation of sexes by salinity was discernable except at a low salinity of 6 to 10 $^{o}/oo$ when nine of the 10 specimens collected were males. This may not be significant, since most of the specimens collected during the study were small individuals.

There appears to be a general lack of detailed information on black drum fecundity. Pearson (1929) estimated fecundity to be approximately 5,976,000 eggs for a 110 cm Texas black drum.

Fecundity was estimated to be approximately 11,398,000 eggs for a 918 mm Georgia black drum. The total weight of this specimen was 20,771 g with the gonads making up approximately 43% (8,863 g) of the fish weight (Figure 33). This specimen exhibited 14 otolith rings.

Food Preference and Feeding Habits

The black drum is a highly specialized bottom feeder as indicated by the general lack of fish and by the high occurrence of benthic organisms such as crabs, mollusks and worms in its regular diet. Table 117 presents the food items found in the stomachs of black drum by fish size in 100 mm length groups. Of 77 stomachs examined, 62 (80.5%) contained food and 15 (19.5%) were empty.

In small drum (<200 mm) the main diet was made up of decapod crustaceans, primarily mud crabs, and annelid worms. Mollusks were absent in the stomachs of these small specimens. In specimens 201-400 mm a variety of organisms were ingested, with decapod crustaceans and annelid worms again the top items. However, in this size group mollusks and unidentified fish parts were also observed. Penaeid shrimp were also of some importance.

In specimens 400-700 mm, major foods were decapod crustaceans and

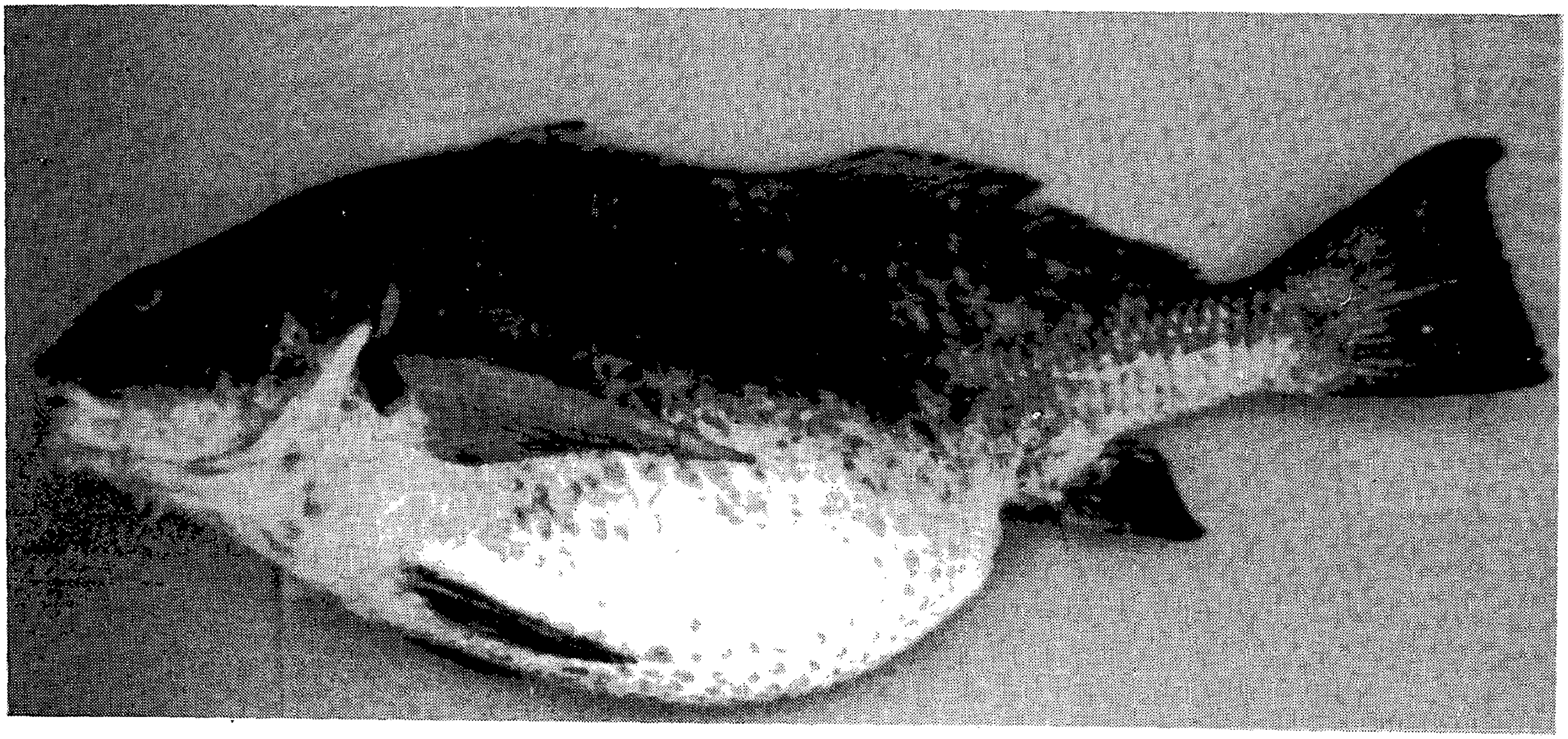

Figure 33. Gravid black drum with ovaries comprising approximately 43% of the body weight. This 918 mm specimen exhibited 14 otolith rings.

Table 117. Stomach contents of Black drum, *Pogonias cromis*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group (mm) 101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	Combined	Percent Occurrence	Average %Bolus
PISCES												
Pisces (Unidentifiable)		2								2	3.2	25
ARTHROPODA												
Crustacea (unidentifiable)		5	7	1						13	21.0	32
Alpheus heterochelis			2				1			3	4.8	33
Caprellidae		1								1	1.6	90
Decapoda	4	10	2	3						19	30.6	63
Eurypanopeus depressus					1					1	1.6	10
Hexapanopeus angustifrons	1									1	1.6	70
Ovalipes ocellatus				1	1		1			3	4.8	40
Palaemonetes sp.			1							1	1.6	10
Panopeus herbstii			1					1		2	3.2	15
Penaeidae		2								2	3.2	90
Penaeus setiferus				1						1	1.6	30
Porcellana sayana		1								1	1.6	50
Rhithropanopeus harrisii	1									1	1.6	10
Sesarma reticulatum	1								1	2	3.2	55
Squilla empusa												
Uca pugilator												
Uca pugnax												

Table 117. (continued)

Food Item	Length Group (mm) 101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	Combined	Percent Occurrence	Average %Bolus
MOLLUSCA												
Mollusca (unidentifiable)		2		3	1		1	1		8	12.9	90
Crassostrea virginica				1					1	2	3.2	80
Mercenaria mercenaria		1		1						2	3.2	<5
Nassarius vibex			2	1						3	4.8	17
ANNELIDA												
Eteone sp.	1									1	1.6	30
Heteromastus filiformis		2								2	3.2	<5
Nereidae		7								7	11.3	26
Nicolea simplex	3	3	3							9	14.5	40
Spionidae	1	2								3	4.8	47
Streblospio benedicti	1	2								3	4.8	7
Tubificidae		1								1	1.6	30
PLANT												
Detritus		2	1	1						4	6.5	33
Spartina alterniflora	1	3	1							5	8.1	32
BRYOZOA												
Anguinella palmata	1									1	1.6	5
INORGANIC MATERIAL	3	8		4						15	24.2	62
ANIMAL TISSUE												
Animal tissue			1							1	1.6	90
Vertebrate bone			1							1	1.6	10

Number of stomachs: 77
Number and percent of stomachs containing food: 62 (80.5%)
Number and percent of empty stomachs: 15 (19.5%)

mollusks, and only one specimen had ingested commercial species of penaeid shrimp. In the largest specimens (>700 mm), there was a definite preference for crabs (lady crabs, *Ovalipes ocellatus*; mud crabs, *Panopeus herbstii*; and wharf crabs, *Sesarma reticulatum*) and mollusks. Of the stomachs containing food, 30.6% contained unidentified decapod crustaceans in addition to numerous identified species of shrimp and crabs. Annelid worms and mollusks ranged next as food items.

Pearson (1929) reported that smaller-sized Texas drum (under 20 cm, or 7.8 in), with less powerful crushing teeth tend to prey on the softer food organisms such as annelid worms and smaller crustaceans. Fish and annelids represented 36 and 32 percent of the food in smaller black drum, respectively. He reported that medium-sized fish consumed larger amounts of mollusks (33%) and crabs and shrimp (28%), and older drum confined their food largely to mollusks (74%) and crabs (16%). Simmons and Breuer (1962) found that the food of very young Texas drum consisted primarily of annelids, small fishes and small crustaceans, while larger drum fed on mollusks and shrimp. Silverman (1979) reported food habits changing with age, with young drum feeding indiscriminately on the most abundant food available. Medium size fish consumed large amounts of mollusks, crabs and shrimp, and older fish confined food largely to mollusks and crabs.

Coastal anglers in Georgia have long recognized that commercial blue crabs and clams are excellent baits for large black drum. It is not uncommon to catch large females over 22.7 kg (50 lb) during the spring spawning season in April. Small specimens are generally taken on fiddler crabs and dead shrimp.

The 10 most frequently occurring food items ingested by black drum are presented by season and sector in Table 118. Major food items ingested during the winter months were annelids, primarily polychaetes, and crustaceans. In spring, major food were decapod crustaceans and bivalve mollusks. During summer, decapod crustaceans were the main diet, with *Uca pugnax* and *U. pugilator* being the most commonly ingested species. In fall, they fed mainly on decapod crustaceans although annelids were also eaten.

The greatest portion of the drum diet in the creeks was crustaceans, although annelid worms were frequently found (Table 118). In the sounds crustaceans, primarily crabs, were the staple food supply, although some annelids and clams (*Mercenaria mercenaria*) were also eaten. On the beaches the diet appeared to differ somewhat as annelid worms were the staple while decapods ranked low. In offshore waters they ingested primarily white shrimp (*Penaeus setiferus*) and lady crabs (*Ovalipes ocellatus*) although mollusks were also eaten.

A seasonal trend in feeding habits can be seen in Table 119. Feeding activity was greatest during the warmer months as over 90% of the stomachs contained food from spring through fall. A reduction in food consumption was evident for specimens collected during the winter as only 48% of the stomachs contained food.

Feeding activity was apparently similar in the creeks and sounds, with 77.1 and 80.0% of the stomachs containing food, respectively (Table 119). Although low numbers were collected from the beaches and offshore waters, all stomachs examined from these sectors contained food.

Water temperature appears to have had some effect on the feeding activity of black drum (Table 50). Feeding activity apparently increased with increase in water temperature. At water temperature below 15°C only 43.5% of the stomachs examined contained food. At temperatures 16 to 25°C all stomachs examined contained food, while at temperatures 26 to 30°C the value dropped slightly to 93.7%.

The effects of lunar phases on feeding activity appear to be most pronounced during periods of dark nights as over 93.3% of the stomachs examined contained food during the three day period before new moon and during the first quarter moon phases (Table 51). However, due to the low number of specimens collected further deductions should not be attempted.

SHEEPSHEAD

Sheepshead (*Archosargus probatocephalus*) are geographically distributed along the Atlantic coast from Nova Scotia to south Florida and in the Gulf of Mexico (Fischer, 1978).

Table 118. The 10 most frequently occurring food items found in the stomachs of black drum, *Pogonias cromis*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Sector	Winter Food Item	Winter No. Stomachs	Winter Percent Occurrence	Winter Average % Bolus	Spring Food Item	Spring No. Stomachs	Spring Percent Occurrence	Spring Average % Bolus	Summer Food Item	Summer No. Stomachs	Summer Percent Occurrence	Summer Average % Bolus
Creeks	Nereidae	4	44.4	45	Unidentified material	2	28.6	90	Decapoda	4	50.0	38
	Decapoda	3	33.3	90	Decapoda	2	28.6	75	Annelida	3	37.5	47
	Unidentified material	3	33.3	77	Crustacea	2	28.6	5	*Uca pugilator*	2	25.0	60
	Alpheus sp.	1	11.1	90	Penaeidae	1	14.3	90	*Uca pugnax*	2	25.0	60
	Bivalvia	1	11.1	50	*Crassostrea virginica*	1	14.3	80	*Sesarma reticulatum*	1	12.5	90
	Palaemonetes sp.	1	11.1	10	*Porcellana sayana*	1	14.3	50	*Squilla empusa*	1	12.5	70
	Crustacea	1	11.1	5	Pisces	1	14.3	40	Unidentified material	1	12.5	30
					Tubificidae	1	14.3	30	*Panopeus* sp.	1	12.5	30
					Sesarma reticulatum	1	14.3	20	*Spartina alterniflora*	1	12.5	10
					Annelida	1	14.3	10	*Rhithropanopeus harrisii*	1	12.5	10
Sounds	Unidentified material	2	66.7	100	Decapoda	4	36.4	83	Crustacea	8	72.7	37
	Spionidae	1	33.3	50	*Sesarma cinereum*	3	27.3	50	Annelida	3	27.3	40
	Eteone sp.	1	33.3	30	*Spartina alterniflora*	3	27.3	50	Decopoda	2	18.2	90
	Streblospio benedicti	1	33.3	20	*Nassarius vibex*	3	27.3	17	*Uca pugnax*	2	18.2	90
					Mercenaria mercenaria	2	18.2	<5	Organic material	2	18.2	60
					Animal tissue	1	9.1	90	Unidentified material	1	9.1	90
					Bivalvia	1	9.1	90	Pisces	1	9.1	10
					Mollusca	1	9.1	90				
					Crassostrea virginica	1	9.1	80				
					Vertebrata (bone)	1	9.1	10				
Beaches	NONE 1/	-	-	-	Spionidae	2	50.0	45	NONE	-	-	-
					Nereidae	2	50.0	20				
					Mediomastus sp.	2	50.0	<5				
					Streblospio benedicti	2	50.0	<5				
					Decapoda	1	25.0	<5				
					Annelida	1	25.0	<5				
					Spartina alterniflora	1	25.0	40				
					Unidentified material	1	25.0	5				
Offshore	NONE	-	-	-	Sand	3	100.0	40	NONE	-	-	-
					Bivalvia	3	100.0	10				
					Decapoda	2	66.7	15				
					Crustacea	1	33.3	30				
					Penaeus setiferus	1	33.3	30				
					Ovalipes ocellatus	1	33.3	20				
					Unidentified material	1	33.3	20				
Totals	Unidentified material	5	41.7	82	Decapoda	9	36.0	57	Crustacea	8	42.1	36
	Nereidae	4	33.3	45	Bivalvia	6	24.0	33	Decapoda	6	31.6	55
	Decapoda	3	25.0	90	Unidentified material	5	20.0	42	Annelida	6	31.6	43
	Alpheus sp.	1	8.3	90	*Spartina alterniflora*	4	16.0	38	*Uca Pugnax*	4	21.1	75
	Bivalvia	1	8.3	50	*Sesarma cinereum*	3	12.0	50	Unidentified material	2	10.5	60
	Spionidae	1	8.3	50	Sand	3	12.0	40	Plant material	2	10.5	60
	Eteone sp.	1	8.3	30	*Ovalipes ocellatus*	3	12.0	40	*Uca pugilator*	2	10.5	60
	Streblospio benedicti	1	8.3	20	*Nassarius vibex*	3	12.0	17	*Sesarma reticulatum*	1	5.3	90
	Palaemonetes sp.	1	8.3	10	Crustacea	3	12.0	10	*Squilla empusa*	1	5.3	70
	Crustacea	1	8.3	<5	Nereidae	3	12.0	<5	*Panopeus* sp.	1	5.3	30

1/ None denotes no specimens were collected with food in stomachs.

Table 118. (continued)

Sector	Fall Food Item	Fall No. Stomachs	Fall Percent Occurrence	Fall Average % Bolus	Combined Totals Food Item	Combined Totals No. Stomachs	Combined Totals Percent Occurrence	Combined Totals Average % Bolus
Creeks	**Penaeidae**	1	33.3	90	**Decopoda**	9	33.3	63
	Annelida	1	33.3	90	**Unidentified material**	6	22.2	73
	Hexapanopeus anguatifrons	1	33.3	70	**Annelida**	5	18.5	48
	Uca Pugnax	1	33.3	30	**Nereidae**	5	18.5	36
	Alpheus **sp.**	1	33.3	10	*Uca pugnax*	3	11.1	50
					Crustacea	3	11.1	<5
					Penaeidae	2	7.4	90
					Uca pugilator	2	7.4	60
					Sesarma reticulatum	2	7.4	55
					Alpheus **sp.**	2	7.4	50
Sounds	**Crustacea**	1	33.3	90	**Crustacea**	9	32.1	42
	Decapoda	1	33.3	90	**Decapoda**	7	25.0	86
	Caprellidae	1	33.3	90	**Unidentified material**	4	14.3	70
	Organic material	1	33.3	10	**Plant material**	4	14.3	33
					Sesarma cinereum	3	10.7	50
					Spartina alterniflora	3	10.7	50
					Annelida	3	10.7	40
					Nassarius vibex	3	10.7	17
					Uca pugnax	2	7.1	90
					Mercenaria mercenaria	2	7.1	<5
Beaches	**NONE** 1/	-	-	-	**Spionidae**	2	50.0	45
					Nereidae	2	50.0	20
					Mediomastus **sp.**	2	50.0	<5
					Streblospio benedicti	2	50.0	<5
					Decapoda	1	25.0	<5
					Annelida	1	25.0	<5
					Spartina alterniflora	1	25.0	40
					Unidentified material	1	25.0	<5
Offshore	**NONE**	-	-	-	**Sand**	3	100.0	40
					Bivalvia	3	100.0	10
					Decapoda	2	66.7	15
					Crustacea	1	33.3	30
					Penaeus setiferus	1	33.3	30
					Ovalipes ocellatus	1	33.3	20
					Unidentified Material	1	33.3	20
Totals	**Crustacea**	1	16.7	90	**Decapoda**	19	30.6	63
	Penaeidae	1	16.7	90	**Crustacea**	13	21.0	32
	Decapoda	1	16.7	90	**Unidentified material**	12	19.4	62
	Caprellidae	1	16.7	90	**Annelida**	9	14.5	40
	Annelida	1	16.7	90	**Bivalvia**	7	11.3	36
	Hexapanopeus angustifrons	1	16.7	70	**Nereidae**	7	11.3	26
	Uca pugnax	1	16.7	30	*Uca pugnax*	5	8.1	66
	Alpheus **sp.**	1	16.7	10	*Spartina alterniflora*	5	8.1	32
	Plant material	1	16.7	10	**Plant material**	4	6.5	33
					Sesarma cinereum	3	4.8	50

[1]None denotes no specimens were collected with food in stomachs.

Table 119. Number and percent of black drum, *Pogonias cromis*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	9	56.3	7	43.7	16	100.0	3	33.3	6	66.7	9	100.0	-	-	-	-	-	-
Spring	7	100.0	0	0.0	7	100.0	11	100.0	0	0.0	11	100.0	4	100.0	0	0.0	4	100.0
Summer	8	88.9	1	11.1	9	100.0	11	91.7	1	8.3	12	100.0	-	-	-	-	-	-
Fall	3	100.0	0	0.0	3	100.0	3	100.0	0	0.0	3	100.0	-	-	-	-	-	-
Total	27	77.1	8	22.9	35	100.0	28	80.0	7	20.0	35	100.0	4	100.0	0	0.0	4	100.0

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	-	-	-	-	-	-	12	48.0	13	52.0	25	100.0
Spring	3	100.0	0	0.0	3	100.0	25	100.0	0	0.0	25	100.0
Summer	-	-	-	-	-	-	19	90.5	2	9.5	21	100.0
Fall	-	-	-	-	-	-	6	100.0	0	0.0	6	100.0
Total	3	100.0	0	0.0	3	100.0	62	80.5	15	19.5	77	100.0

This species uses its large, strong teeth to pick, gnaw, and scrape oysters, barnacles, crabs and clams off submerged pilings and rocks. Hence, concentrations of sheepshead are found near oyster reefs, piers, docks, jetties, bridges and over other areas where shellfish are plentiful. In general, larger sheepshead move to offshore live bottom and reef areas during the colder months and remain in offshore waters through the spring spawning season with many returning to the lower estuarine areas in late spring and summer. Juveniles are abundant throughout the estuarine areas during the warmer months but generally move to either the higher salinity areas or to deep water where they are less available for collection during the colder months.

Movement and Migration

From May 23, 1979 through June 22, 1982, 416 sheepshead were tagged and released. Length frequencies of tagged sheepshead in 50 mm length groups are presented in Table 120. Lengths (TL) of sheepshead tagged with Howitt tags ranged from 130 to 540 mm, and those tagged with Floy tags ranged 140 to 530 mm. Length frequencies of sheepshead tagged with each tag type are presented in Table 121. Of 416 sheepshead tagged, only one fish was tagged with both tag types. Table 122 lists the length frequencies of tagged sheepshead in 20 mm groups by gear type used for recapture.

Tagged sheepshead were returned from September 11, 1979 through September 12, 1982. Of 416 fish tagged, 30 (7.2%) were recaptured and tags returned. Recovery rates, for fish separated into 50 mm length groups, ranged as high as 22.2%. The number of sheepshead released and recaptured, time at large, and distance traveled are shown in Table 120. Time at large ranged from 5 to 739 days, averaging 240 days. Distance traveled ranged as far as 98 km, averaging 8.1 km.

Recovery rates were 8.2% with Howitt tags and only 1.6% with Floy tags (Table 121). Recovery rates for sheepshead separated into 50 mm length groups ranged as high as 25.0% with Howitt tags and 5.3% with Floy tags. The one sheepshead tagged with both tag types was not returned.

Table 120. Number tagged, number and percent recaptured, days at large and distance traveled for sheepshead, *Archosargus probatocephalus*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large		Distance Traveled (km) 1/	
				Avg.	Max.	Avg.	Max.
101 - 150	15	0	0.0				
151 - 200	38	2	5.3	212	375	7.6	12
201 - 250	134	11	8.2	264	684	7.2	30
251 - 300	138	10	7.2	260	557	13.7	98
301 - 350	53	3	5.7	84	223	0.2	1
351 - 400	18	1	5.6	243	243	6.5	7
401 - 450	9	2	22.2	14	22	0.5	1
451 - 500	7	1	14.3	739	739	3.7	4
501 - 550	4	0	0.0				
Total	416	30	7.2	240	739	8.1	98

1/ Distance measured in kilometers from point of release to point of recapture.

Table 121. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for sheepshead, *Archosargus probatocephalus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
125	9			6			15		
175	19	1	5.3	19	1	5.3	38	2	5.3
225	115	11	9.6	19			134	11	8.2
275	124	10	8.1	14			138	10	7.2
325	51	3	5.9	2			53	3	5.7
375	18	1	5.6				18	1	5.6
425	8	2	25.0	1			9	2	22.2
475	7	1	14.3				7	1	14.3
525	3						3		
Total	354	29	8.2	61	1	1.6	415	30	7.2

NOTE: Number tagged and recaptured does not include the one fish tagged with both tag types.

Table 122. Number of sheepshead, *Archosargus probatocephalus*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Length Group	Gill Net (in)[1/]					Trammel		Cast			
(mm)	2-7/8	3-1/2	4-5/8	6	8-1/2	Net	Trawl	Net	Trap	Hook/Line	Totals
130	-	-	-	-	-	-	-	-	5	-	5
150	-	-	-	-	-	-	1	5	12	1	19
170	-	-	1	-	-	-	-	4	10	4	19
190	-	-	-	-	-	-	-	3	2	5	10
210	1	-	-	-	-	-	-	4	2	21	28
230	1	-	1	-	-	2	-	2	3	55	64
250	1	-	-	-	-	3	-	2	4	77	87
270	1	-	-	-	-	1	-	1	4	40	47
290	5	-	-	-	-	2	-	1	4	34	46
310	2	-	-	-	-	2	-	-	1	24	29
330	4	-	-	-	-	2	-	-	-	12	18
350	-	-	-	-	-	-	-	-	-	10	10
370	2	-	1	-	-	1	-	-	-	5	9
390	1	-	-	-	-	1	-	-	-	3	5
410	2	1	-	-	-	-	-	-	-	1	4
430	1	-	-	-	-	1	1	-	-	2	5
450	-	-	-	-	-	1	-	-	-	1	2
470	1	-	-	1	-	-	-	-	-	-	2
490	2	-	-	-	1	-	-	-	-	-	3
510	1	-	-	-	-	-	-	-	-	-	1
530	2	-	-	-	-	-	1	-	-	-	3
Totals	27	1	3	1	1	16	3	22	47	295	416

[1/] Gill net sizes are stretch mesh measurements.

Recreational fishermen were the major source of sheepshead recoveries, accounting for 23 (76.7%) of 30 returns. Study activities accounted for 7 (23.3%) recoveries, while commercial fishermen failed to return any recaptures (Table 11). Of 23 recreational recaptures, 15 (65%) included sufficient information to determine lengths of creel size fish. Lengths (TL) of recreational recaptures for sheepshead ranged from 192 to 393 mm with an average size of 300 mm (Table 12). Length frequencies of recaptures indicated that most creel size fish were over 250 mm (Table 13).

Of 30 recoveries 29 specimens produced sufficient information to determine the sector and season of recapture. The creeks produced the highest return rate of 62.1% (Table 14). However, the recovery rate in the sounds was proportionally higher than the number released in this sector, indicating higher fishing pressure. Spring produced most of the recoveries (37.9%) while none were recaptured during winter (Table 15).

Georgia residents fishing in state waters accounted for 21 (70%) of the 30 recreational recaptures. Of these resident anglers, 18 (86%) traveled 40 km or less to reach the location of recapture, while approximately 95% traveled less than 120 km (Table 16).

Fiddler crabs were the principal bait used by recreational fishermen to catch sheepshead (Table 17). Approximately 74% of all recreational recoveries were on fiddlers, and the remaining recoveries were caught with live and dead shrimp (17 and 8 percent, respectively).

Approximately 37% of the sheepshead recoveries were caught in the immediate area of release, with 28 (93%) captured within 25 km of the release site (Table 123). Only two recoveries traveled more than 25 km. These fish were at large 557 and 684 days and traveled southward 98 and 30 km, respectively. Spring was the season of greatest movement with fish moving an average distance of 17.9 km prior to recapture (Table 21). Winter recaptures exhibited the least movement with average and maximum distances of only 1.5 and 4.4 km, respectively.

Although recovery data indicate most sheepshead do not migrate great distances, the species appears to exhibit random movement within

Table 123. Days at large and distance traveled for sheepshead, *Archosargus probatocephalus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Days At	Distance traveled (km)							
Large	0	0.1-1	1-5	6-25	26-50	51-100	Total	Percent
1 - 50	5	1	2	1	-	-	9	30.0
51 - 100	2	-	-	1	-	-	3	10.0
101 - 150	-	-	-	-	-	-	-	-
151 - 200	-	-	-	-	-	-	-	-
201 - 300	1	1	1	2	-	-	5	16.7
301 - 500	3	-	3	4	-	-	10	33.3
501 - 750	-	-	1	-	1	1	3	10.0
Total	11	2	7	8	1	1	30	100.0
Percent	36.7	6.7	23.3	26.7	3.3	3.3	100.0	

the estuarine system. Recovery data were insufficient to determine seasonal movement trends within the estuary (Table 124). When sheepshead did emigrate out of the estuary, they generally moved near offshore reefs, with some tendency to move southward.

Length-Weight Relationship

The length-weight relationship for 118 sheepshead, ranging from 101 to 591 mm (TL) and 21 to 4,297 g, was $\log W = 2.885 \log L - 4.412$. The correlation coefficient value for length-weight was 0.9707 ($P < 0.0001$). Least-squares regression analyses on the length-weight relationships for male and female, and all sheepshead combined are presented in Table 24. Figure 34 illustrates length-weight relationship for sheepshead. The greatest lengths recorded were 563 mm for males and 591 mm for females. The heaviest male and female were 2,962 and 4,297 g, respectively.

Age and Growth

Although sciaenids have received extensive research on the Atlantic and Gulf coasts, comparatively limited work has been published for sheepshead. Published information pertaining to age and growth was limited.

Scales from 118 sheepshead ranging from 101 to 591 mm were examined and scales from 105 (88%) were determined to be usable for age analyses. Otoliths from 105 specimens were also examined to document the validity of annuli counts ascertained from scales. Annuli formation on the anterior portion of sheepshead scales appear as abrupt, irregular changes or breaks in the circuli patterns. Also, new circuli cutting over the incomplete circuli in the lateral areas of the scales were identified as annuli.

Calculation of mean monthly growth of marginal increments of sheepshead less than five years old validated that scale annuli were formed only once annually. A single annulus formation was detectable on young sheepshead scales during February and March, with all scales bearing recent annuli by early April. Calculations indicated similar findings

Table 124. Seasonal movement of sheepshead, *Archosargus probatocephalus*, tagged in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Season	Length Group (mm)	Caught In Area Of Release	Direction Moved By Recaptured Tagged Fish: Movement Within Estuary: Creek to Beach	Beach To Creek	Movement Out Of Estuary: North	South
Winter	No Recaptures					
Spring	151-200	-	-	-	-	1
	201-250	1	2	-	1	-
	251-300	-	2	1	-	1
	301-350	1	-	-	-	-
	351-400	-	1	-	-	-
	401-450	-	-	-	-	-
	451-500	-	-	-	-	-
	Total	2	5	1	1	2
	Percent	18.2	45.4	9.1	9.1	18.2
Summer	151-200	-	-	-	-	-
	201-250	2	-	-	-	3
	251-300	1	1	-	-	-
	301-350	1	-	-	-	-
	351-400	-	-	-	-	-
	401-450	-	-	-	-	-
	451-500	-	-	-	-	-
	Total	4	1	-	-	3
	Percent	50.0	12.5	-	-	37.5
Fall	151-200	-	-	-	-	1
	201-250	1	-	-	-	1
	251-300	2	-	1	-	2
	301-350	-	-	-	-	-
	351-400	-	-	-	-	-
	401-450	-	-	-	-	1
	451-500	-	1	-	-	-
	Total	3	1	1	-	5
	Percent	30.0	10.0	10.0	-	50.0
Combined	Total	9	7	2	1	10
	Percent	31.1	24.1	6.9	3.4	34.5

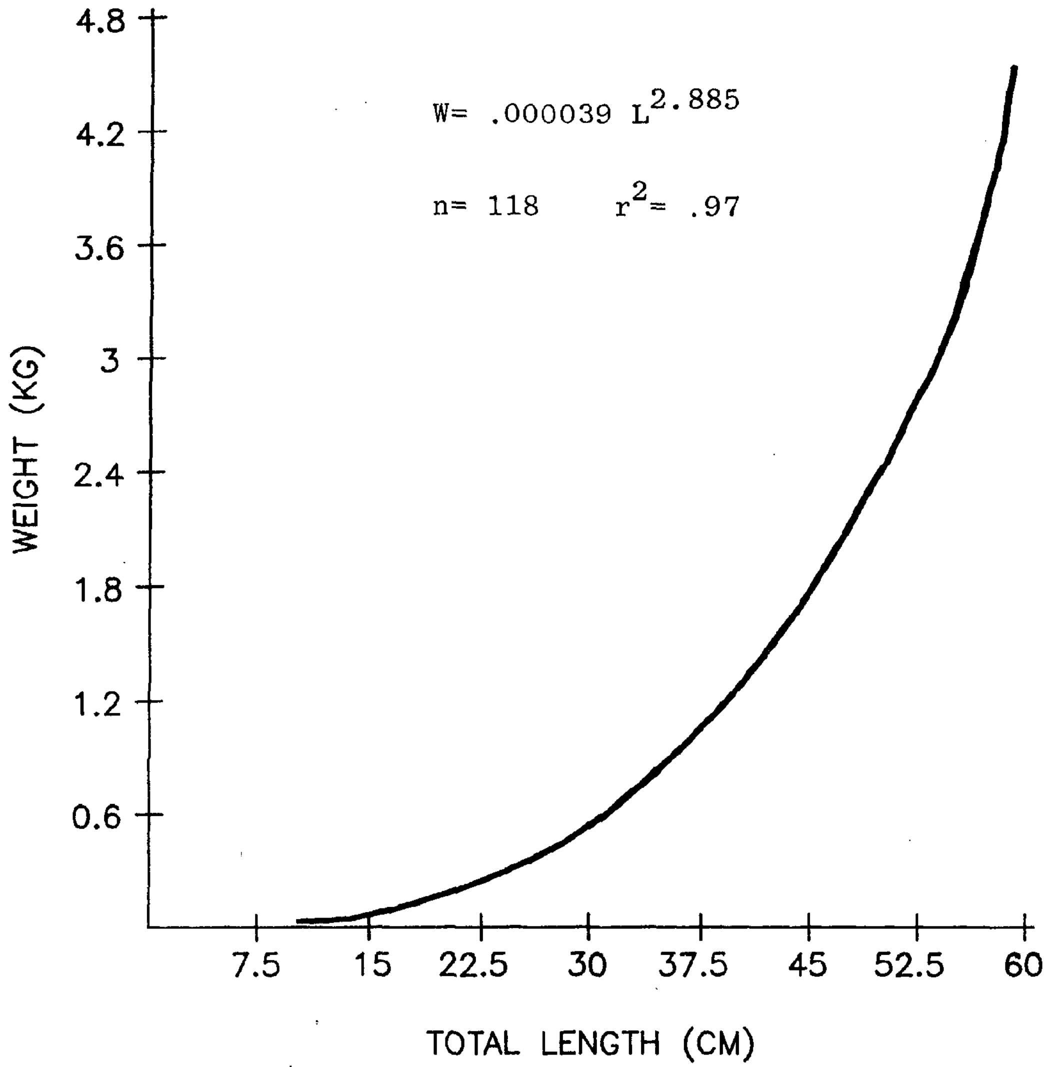

Figure 34. Length-weight relationship of sheepshead, *Archosargus probatocephalus*, collected in Glynn County, Georgia from January 1979 through June 1982.

for older specimens, but approximately 90% of all fish over four years old were collected during April, May, and June. Therefore, documentation of time of annulus formation and number of annuli formed each year by older fish was limited.

Least-squares regression analyses on the relationship between fish length and scale radius were performed. The correlation coefficient value of 0.89 ($P < 0.0001$) suggests the relationship was sufficiently linear to warrant direct proportion calculations to determine fish length at time of annulus formation. The empirical and mean back-calculated total lengths at age for sheepshead are presented in Table 125. Figure 35 illustrates length-age relationships, and Table 126 shows the empirical and weighted mean back-calculated lengths for juvenile, male, female, and all sheepshead combined. Length-age equations for sheepshead are shown in Table 27.

To document estimates of growth obtained from back-calculations, growth rates of five tagged specimens at large from 11 to 13 months were determined. Lengths when tagged ranged 175 - 239 mm and averaged 215 mm, and the mean growth increase was 80.6 mm. The empirical annual growth was slightly less than estimates from back-calculations. However, agreement between empirical and estimated growth rates from back-calculations were sufficient to document growth rates of sheephead.

Maturity and Spawning

During the study, the smallest sheepshead examined for which sex could be determined through gross examination was 200 mm for females and 187 mm for males. Both of these fish were age 0 or in their first year of life. The smallest female to show developing ovaries (stage III or greater) was a 282 mm specimen (age III) while the smallest male was 393 mm (age IV). Growth and development of larval and young have been described by Hildebrand and Cable (1938) and by Mook (1977). However, a review of the available literature showed a general lack of information as to size and age at maturity and spawning for this species.

Although sheepshead are found throughout the marine environment in Georgia, spawning activity appears to be centered in offshore waters.

Table 125. Mean back-calculated total lengths for sheepshead, *Archosargus probatocephalus*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Ring Class	Number	Length-Range at Capture	Mean Length at Capture	Mean Back-Calculated Lengths of Successive Scale Rings													
				1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	10	101 - 182	145														
1	20	209 - 286	244	164													
2	29	212 - 350	273	154	246												
3	8	301 - 399	364	147	256	319											
4	11	332 - 465	404	137	254	336	388										
5	1	418	418	114	262	345	391	417									
6	7	435 - 526	465	146	253	330	378	427	459								
7	6	485 - 540	508	147	270	363	411	451	478	501							
8	4	473 - 537	512	146	258	328	393	430	465	490	507						
9	2	555 - 563	559	142	278	359	417	470	516	531	546	553					
10	2	568 - 578	573	136	246	313	364	416	442	484	525	550	561				
11	2	493 - 542	518	127	254	310	362	410	442	465	483	492	501	513			
12	1	563	563	136	264	307	357	420	459	488	513	531	538	548	557		
13	0																
14	1	591	591	136	273	369	430	491	520	534	542	552	558	569	575	582	588
		Weighted Means		150	253	334	390	436	469	497	516	534	536	536	566	582	588
		Growth Increments		150	103	81	56	46	33	28	19	18	2	0	30	16	6

NOTE: Lengths measured in millimeters.

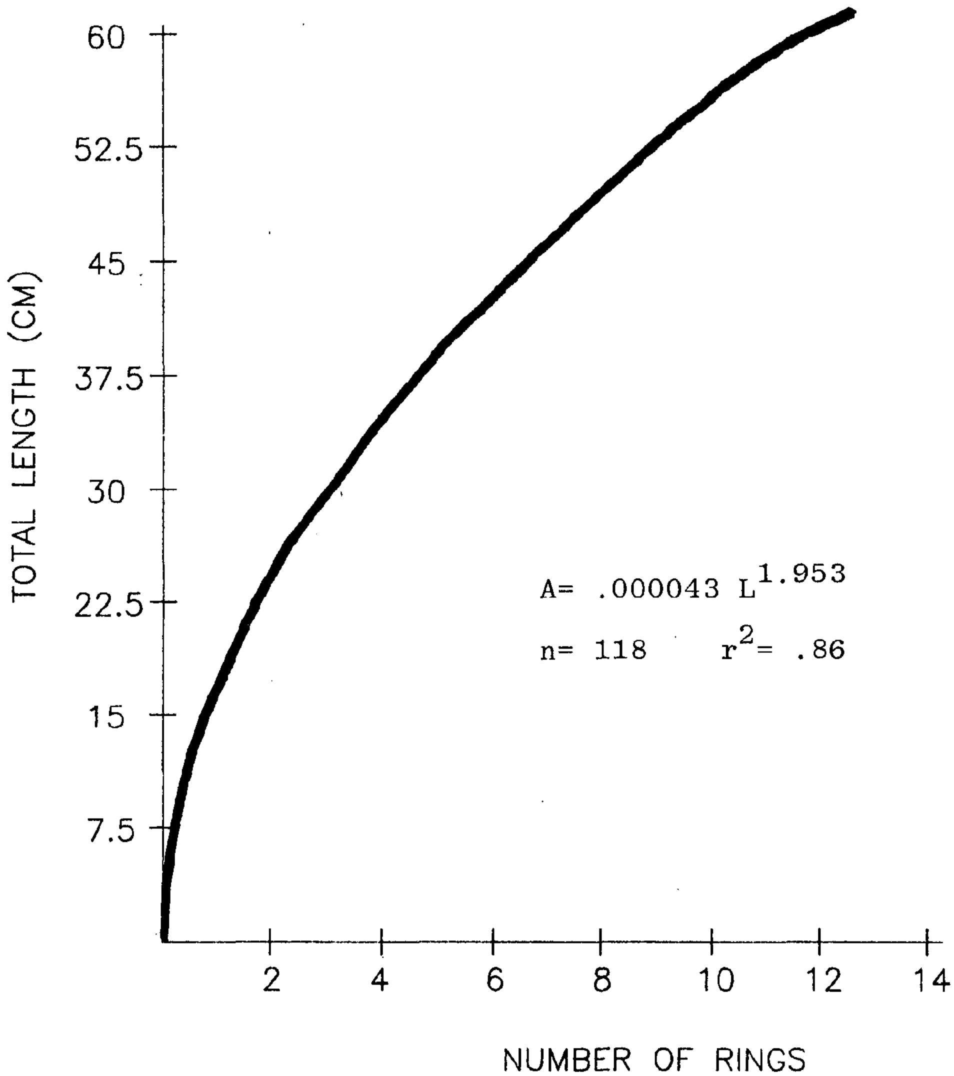

Figure 35. Length-age relationship of sheepshead, *Archosargus probatocephalus*, collected in Glynn County, Georgia.

Table 126. Number, empirical and back-calculated total lengths, and growth increments by sex and age for sheepshead, *Archosargus probatocephalus*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

	Scale Ring Class													
Sex	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Juveniles														
Number	3	6	0	1										
Mean Length at Capture	232	277		347										
Back Calculated Length	144	240	296	328										
Growth Increment	144	96	56	32										
Males														
Number	8	9	0	5	1	3	1	3	1	0	1			
Mean Length at Capture	252	250		412	418	454	516	514	563		493			
Back Calculated Length	146	253	342	390	425	459	487	505	507	469	485			
Growth Increment	146	107	89	48	35	34	38	18	2		16			
Females														
Number	9	15	8	5	0	4	5	1	1	2	1	1	0	1
Mean Length at Capture	241	285	364	409		480	506	505	555	573	542	563		591
Back Calculated Length	146	256	332	393	443	474	502	524	541	551	552	566	582	588
Growth Increment	146	110	76	61	50	31	28	22	17	10	1	14	16	6
Combined														
Number	20	29	8	11	1	7	6	4	2	2	2	1	0	1
Mean Length at Capture	244	273	364	404	418	465	508	512	559	573	518	563		591
Back Calculated Length	150	253	334	390	436	469	497	516	534	536	537	566	582	588
Growth Increment	150	103	81	56	46	33	28	19	18	2	1	30	16	6

NOTE: Lengths measured in millimeters.

Ovarian development was first observed in March when one stage III female was found. However, spawning was apparently fully underway in April when advanced maturities (stages IV through VI) were collected in numbers (Table 127). All of these spawners were collected in April at artificial reef "WR2" approximately 13 nautical miles offshore from Cumberland Island, Georgia. These 22 adults were collected by speargun in water approximately 16 meters (50 ft) deep over artificial reef habitat consisting of sunken automobile tires and an old steel ship from World War II and over otherwise barren sand bottoms.

Adult sheepshead are commonly taken by recreational anglers on nine of Georgia's artificial reefs as well as on the natural live bottom area known as Gray's Reef National Marine Sanctuary approximately 16 nautical miles offshore from Sapelo Island. Consequently, spawning probably takes place at each site during early spring. Spawning at inshore areas was not encountered during our sampling, but one recreational sheepshead angler reported taking sheepshead with advanced ovarian development in Dupelin River behind Sapelo Island in April 1983 (Mr. Ernest Robarts, personnel communication).

Since all advanced stages of maturity were collected from offshore waters in April, it is assumed that this is when and where peak sheepshead spawning activity is centered. These 22 spawners were collected at salinities of 36 $^{o}/oo$ and at temperatures of 21-25^{o}C (Tables 128 and 129). Our findings agree with results of investigations in other areas that spawning generally takes place in spring from April through June in ocean waters. Rathbun (1892) reported sheepshead spawning along sandy shores in late evening in southwest Florida. Hildebrand and Cable (1938) concluded from the collections of young and one developing roe sheepshead that spawning in the Beaufort, N.C. area was from April through June. McClane (1965) reported that although data were scarce, spawning apparently takes place in the spring. Mook (1977) reported that sheepshead spawn in the spring (April and May) in temperate North Carolina and as early as the first part of March in subtropical southern Florida.

Table 127. Number of sheepshead, *Archosargus probatocephalus*, collected by month, sex and reproductive stage for the period January 1979 through June 1982.

	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
Month	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	2	0												
February			5	1										
March	2	1			1	0								
April					0	2	0	4	10	4	2	0		
May	5	9	3	0										
June	7	2	1	1										
July	3	1												
August	4	1												
September	5	2	1	0										
October	3	1												
November	7	7												
December			0	1										

Table 128. Stages of gonadal development for sheepshead, *Archosargus probatocephalus*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

		Surface Water Salinity (0/00)																	
	Reproductive	0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		Totals	
Month	Stage	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	I	-	-	-	-	-	-	-	-	2	0	-	-	-	-	-	-	2	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	1	0	3	1	1	0	-	-	-	-	5	1
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I	-	-	-	-	-	-	-	-	1	0	-	-	1	1	-	-	2	1
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	2	0	2
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	4	0	4
	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	4	10	4
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	2	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	I	-	-	-	-	4	6	-	-	-	-	0	1	-	-	1	2	5	9
	II	-	-	-	-	1	0	-	-	1	0	-	-	-	-	1	0	3	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	I	-	-	-	-	-	-	-	-	6	1	0	1	1	0	-	-	7	2
	II	-	-	-	-	-	-	-	-	1	0	0	1	-	-	-	-	1	1
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
July	I	-	-	-	-	-	-	-	-	-	-	1	0	2	1	-	-	3	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	I	-	-	-	-	-	-	-	-	2	0	1	1	1	0	-	-	4	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I	-	-	-	-	-	-	1	0	-	-	4	2	-	-	-	-	5	2
	II	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I	-	-	-	-	-	-	-	-	2	0	1	0	0	1	-	-	3	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I	-	-	-	-	-	-	-	-	6	6	1	1	-	-	-	-	7	7
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-	0	1	-	-	0	1
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combined Total	I	-	-	-	-	4	6	1	[illegible]	19	7	8	6	5	3	1	2	38	24
	II	-	-	-	-	1	0	1	0	5	1	2	1	0	1	1	0	10	3
	III	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0	2	1	2
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	4	0	4
	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	4	10	4
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	2	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 129. Stages of gonadal development for sheepshead, *Archosargus probatocephalus*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)		Surface Water Temperature (°C) 0-5		6-10		11-15		16-20		21-25		26-30		31-35		Totals	
		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
11-15	I	-	-	-	-	1	0	-	-	3	6	-	-	-	-	4	6
	II	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-20	I	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	II	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-25	I	-	-	2	0	-	-	7	6	-	-	10	1	-	-	19	7
	II	-	-	-	-	-	-	3	1	-	-	2	0	-	-	5	1
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-30	I	-	-	-	-	-	-	1	1	1	1	5	3	1	1	8	6
	II	-	-	1	0	-	-	-	-	-	-	1	1	-	-	2	1
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-35	I	-	-	-	-	-	-	-	-	1	0	4	2	-	-	5	2
	II	-	-	-	-	-	-	0	1	-	-	-	-	-	-	0	1
	III	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36-40	I	-	-	-	-	-	-	-	-	1	2	-	-	-	-	1	2
	II	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	III	-	-	-	-	-	-	-	-	0	2	-	-	-	-	0	2
	IV	-	-	-	-	-	-	-	-	0	4	-	-	-	-	0	4
	V	-	-	-	-	-	-	-	-	10	4	-	-	-	-	10	4
	VI	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	I	-	-	2	0	1	0	8	7	6	9	20	6	1	1	38	23
	II	-	-	1	0	1	0	4	2	1	0	3	1	0	0	10	3
	III	-	-	-	-	-	-	-	-	1	2	-	-	-	-	1	2
	IV	-	-	-	-	-	-	-	-	0	4	-	-	-	-	0	4
	V	-	-	-	-	-	-	-	-	10	4	-	-	-	-	10	4
	VI	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Since all advanced maturities were collected at once, no hard facts can be correlated between spawning activity and lunar phases. However, these advanced maturities were collected three days prior to new moon (Table 40). No other advanced stages were collected because of sample design.

Female sheepshead outnumbered males 1.7:1 (Table 41), and dominated catches at all salinity levels except 11-15 $^{o}/oo$ where males comprised 54.5% of 11 specimens sampled (Table 128).

A literature review of investigations dealing with sheepshead revealed a general lack of information on fecundity for this species in the Gulf of Mexico and Atlantic coast waters.

Since offshore waters were beyond the general study area, collections of advanced reproductive maturity stages of sheepshead were limited. Fecundity estimates were determined for 12 sheepshead ranging in length and weight from 428 to 591 mm and 1,647 to 4,297 g, respectively. These 12 specimens exhibited otolith ring counts from 4 to 14. Mean estimated fecundity was 604,559 eggs with a range from 296,000 to 963,000. Fecundity data for Georgia sheepshead are presented in Table 130.

Food Preference and Feeding Habits

Sheepshead are adapted to a grazing type of feeding behavior as they have large crushing type teeth that allow them to eat a variety of hard bodied crustaceans and mollusks that exist on and attach to pilings, rocks, and natural reefs. In Georgia they are most often taken by recreational anglers using fiddler crabs and fishing around pilings under bridges and docks in inland waters and on man-made reefs in offshore waters.

Table 131 presents the food items ingested by sheepshead by fish size in 100 mm length groups. Of 117 sheepshead stomachs examined, 102 (87.2%) contained food and 15 (12.8%) were empty. There appears to be little difference in food types preferred by different size groups except for a greater inclusion of mollusks, echinoderms and urochordates with increase in size. In smaller specimens (<200 mm)

Table 130. Estimated fecundity for 12 sheepshead, *Archosargus probatocephalus*, collected approximately 21 miles southwest of St. Simons Island, Georgia during April, 1982.

Ring Class	Number of Fish	Total Length (mm)		Mean Fish Weight (g)	Percent Gonad Weight	Estimated Fecundity (X1000)	
		Mean	Range			Mean	Range
4-6	4	466	428 - 526	2,091	7.0	489.3	335.1 - 660.6
7-9	5	514	485 - 555	2,740	8.6	648.3	295.6 - 930.6
10-14	3	574	563 - 591	3,769	12.0	795.1	678.7 - 962.6
Combined	12	513	428 - 591	2,780	8.3	604.6	295.6 - 962.6

Table 131. Stomach contents of Sheepshead, *Archosargus probatocephalus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group (mm) 101-200	201-300	301-400	401-500	501-600	Combined	Percent Occurrence	Average % Bolus
PISCES								
Pisces (unidentifiable)		1		1	1	3	2.9	7
ARTHROPODA								
Crustacea (unidentifiable)	1	1	2	1		5	4.9	42
Amphipoda		1				1	1.0	10
Callinectes sapidus				1		1	1.0	90
Chthamalus fragilis	3	5	2	7	2	19	18.6	41
Cirripedia				1		1	1.0	<5
Corophiidae	1					1	1.0	20
Cyathura polita		2				2	2.0	20
Decapoda		11	3	4		18	17.6	33
Ericthonius brasiliensis					1	1	1.0	90
Eurypanopeus depressus			1	1		2	2.0	25
Gammarus mucronatus					1	1	1.0	<5
Ovalipes ocellatus			2	2	2	6	5.9	52
Panopeus herbstii		2	1	1		4	3.9	15
Portunus gibbesii		1			3	4	3.9	45
Rhithropanopeus harrisii			1			1	1.0	60
Sesarma cinereum		2	1	1		4	3.9	28
Sesarma reticulatum		8	1	1		10	9.8	24
Uca pugilator		2	1			3	2.9	63
Uca pugnax		11	3			14	13.7	46
MOLLUSCA								
Mollusca (unidentifiable)	1	4	4	4	3	16	15.7	37
Cardium pinnatulum				1		1	1.0	<5
Crassostrea virginica		7	5	5	2	19	18.6	47
Fossor conquina					1	1	1.0	<5
Littorina littorea	1					1	1.0	20
Modiolus demissus		3	6	2	1	12	11.8	38
Nassarius vibex		1	1	1		3	2.9	13
Nudibranchia				1		1	1.0	20
Oliva sayana				1		1	1.0	10
Urosalpinx cinerea		2				2	2.0	5

Table 131. (continued)

Food Item	Length Group (mm) 101-200	201-300	301-400	401-500	501-600	Combined	Percent Occurrence	Average % Bolus
COELENTERATA								
Astrangia danae sp.			1		1	2	2.0	20
Hydroids (unidentifiable)		2				2	2.0	80
ANNELIDA and ASCHELMENTHES								
Nematoda			1			1	1.0	<5
Tubificidae				3		3	2.9	23
Sabellariidae				1		1	1.0	90
ECHINODERMATA								
Arbacia punctulata				1	1	2	2.0	80
Asterias forbesi			1	1		2	2.0	30
Echinarachnius parma			1	1	1	3	2.9	27
Ophiodrema brevispina					1	1	1.0	10
PLANT								
Detritus	2	5				7	6.9	70
Spartina alterniflora		2	4			6	5.9	18
Ulva lactuca	1	3	1	1		6	5.9	27
INORGANIC MATERIAL	2	3	4	5	2	16	15.7	43
PORIFERA								
Haliclona oculata		1		1		2	2.0	10
UROCHORDATA								
Ascidiacea			2	4	3	9	8.8	46
Molgula sp.		9	6			15	14.7	37
Perophora viridis		1	1	1		3	2.9	33
Sessile tunicates		2		1		3	2.9	30
BRYOZOA								
Anguinella palmata		26	6	1		33	32.4	35
ANIMAL TISSUE	1					1	1.0	50

Number of stomachs: 117
Number and percent of stomachs containing food: 102 (87.2%)
Number and percent of empty stomachs: 15 (12.8%)

the major food sources were crustaceans and mollusks, but plant detritus, sea lettuce (*Ulva lactuca*), and inorganic materials were also found. However, too few specimens were collected for this smaller size group to determine specific food preferences. One of the major items found in this size group was barnacles (*Chthamalus fragilis*). In specimens 201-300 mm, the major foods were decapod crustaceans, primarily mud fiddler crabs (*Uca pugnax*) and wharf crabs (*Sesarma reticulatum*). Sea grapes (*Molgula* sp.) and the common oyster (*Crassostrea virginica*) were also frequently occurring items. Bryozoans were found in many stomachs, but were probably ingested incidentally while grazing for other species. In specimens over 301 mm crustaceans and mollusks were the main food items. The common oyster was the top food item followed closely by the ribbed mussel (*Modiolus demissus*), barnacles, and ascidians.

The 10 most frequently occurring food items in sheepshead stomachs are presented by season and sector in Table 132. In general, the most frequently occurring items throughout the year were bryozoans, oysters, barnacles, and decapod crustaceans. During winter, barnacles, sea lettuce, bivalve mollusks, and crustaceans were the most frequently occurring items (Table 132). In spring, foods were primarily barnacles, bryozoans and sea grapes. In summer, bryozoans, oysters, barnacles, and fiddler crabs were the top items. In fall, the major foods were oysters and mussels followed by mud and fiddler crabs and sea grapes.

Major food items in the creeks were bryozoans, sea grapes, fiddler crabs and oysters. In the sounds mollusks were of major importance as oysters, mussels and unidentified bivalves were common foods. However, crustaceans were also important with several species of mud crabs and the common blue crab (*Callinectes sapidus*) being observed. No sheepshead were collected from the beaches for food habitat studies. In offshore waters major foods were barnacles, bivalve mollusks, ascidians and the common lady crab (*Ovalipes ocellatus*).

There was an increase in feeding activity from spring and summer to fall as the percentage of stomachs containing food rose steadily from 86.3 to 96.4% (Table 133). During winter, feeding activity dropped

Table 132. The 10 most frequently occurring food items found in the stomachs of sheepshead, *Archosargus probatocephalus*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Winter				Spring				Summer			
Sector	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus
Creeks	*Chthamalus fragilis*	3	33.3	73	*Anguinella palmata*	15	75.0	41	*Anguinella palmata*	7	58.3	37
	Unidentified material	2	22.2	85	*Molgula* sp.	8	40.0	48	Decapoda	5	41.7	38
	Ulva lactuca	2	22.2	55	*Chthamalus fragilis*	6	30.0	37	*Uca pugilator*	2	16.7	75
	Mollusca	2	22.2	20	*Uca pugnax*	5	25.0	60	*Uca pugnax*	2	16.7	45
	Crustacea	1	11.1	90	*Spartina alterniflora*	4	20.0	10	Inorganic material	2	16.7	45
	Ericthonius brasiliensis	1	11.1	90	Decapoda	3	15.0	20	*Molgula manhattensis*	2	16.7	45
	Plant detritus	1	11.1	70	*Sesarma cinereum*	3	15.0	17	*Crassostrea virginica*	2	16.7	40
	Animal tissue	1	11.1	50	*Crassostrea virginica*	2	10.0	45	*Urosalpinx cinerea*	2	16.7	5
	Corophiidae	1	11.1	20	Unidentified material	2	10.0	45	*Sesarma reticulatum*	1	8.3	30
	Littorina littorea	1	11.1	20	*Nassarius vibex*	2	10.0	15	*Portunus gibbesii*	1	8.3	20
Sounds	Bivalvia	2	66.7	55	*Spartina alterniflora*	1	100.0	50	Crustacea	2	33.3	50
	Crassostrea virginica	2	66.7	35	Unidentified material	1	100.0	50	*Callinectes sapidus*	1	16.7	90
	Panopeus sp.	1	33.3	30					*Crassostrea virginica*	1	16.7	90
	Eurypanopeus depressus	1	33.3	30					Unidentified material	1	16.7	90
	Sesarma reticulatum	1	33.3	20					*Sesarma cinereum*	1	16.7	60
	Ulva lactuca	1	33.3	10					*Rhithropanopeus harrisii*	1	16.7	60
									Decapoda	1	16.7	40
									Spartina alterniflora	1	16.7	20
									Anguinella palmata	1	16.7	10
									Panopeus sp.	1	16.7	<5
Beaches	NONE 1/	-	-	-	NONE	-	-	-	NONE	-	-	-
Offshore	NONE	-	-	-	*Chthamalus fragilis*	10	43.5	33	Bivalvia	2	100.0	45
					Bivalvia	6	26.1	42	*Echinarachnius parma*	2	100.0	30
					Ascidiidae	6	26.1	28	Decapoda	2	100.0	15
					Ovalipes ocellatus	5	21.7	62	Unidentified material	1	100.0	20
					Unidentified material	4	17.4	23	*Asterias forbesi*	1	100.0	10
					Portunus gibbesii	3	13.0	53	Sand	1	100.0	<5
					Decapoda	3	13.0	30				
					Tubificidae	3	13.0	23				
					Crassostrea virginica	2	8.7	80				
					Pisces	2	8.7	20				
Totals	*Chthamalus fragilis*	3	25.0	73	*Chthamalus fragilis*	16	36.4	34	*Anguinella palmata*	8	42.1	34
	Ulva lactuca	3	25.0	40	*Anguinella palmata*	15	34.1	41	Decapoda	8	42.1	33
	Unidentified material	2	16.7	85	*Molgula* sp.	8	18.2	48	*Crassostrea virginica*	3	15.8	57
	Bivalvia	2	16.7	55	Unidentified material	8	18.2	29	Crustacea	3	15.8	37
	Crassostrea virginica	2	16.7	35	Ascidiidae	7	15.9	46	*Uca pugilator*	2	10.5	75
	Mollusca	2	16.7	20	*Uca pugnax*	6	13.6	53	Unidentified material	2	10.5	55
	Crustacea	1	8.3	90	*Ovalipes ocellatus*	6	13.6	52	*Uca pugnax*	2	10.5	45
	Ericthonius brasiliensis	1	8.3	90	Bivalvia	6	13.6	28	Inorganic material	2	10.5	45
	Plant detritus	1	8.3	70	Decapoda	6	13.6	25	*Molgula manhattensis*	2	10.5	45
	Eurypanopeus depressus	1	8.3	30	*Spartina alterniflora*	5	11.4	18	Bivalvia	2	10.5	45

1/ None denotes no specimens were collected with food in stomachs.

Table 132. (continued)

Sector	Fall: Food Item	Fall: No. Stomachs	Fall: Percent Occurrence	Fall: Average % Bolus	Combined Totals: Food Item	Combined Totals: No. Stomachs	Combined Totals: Percent Occurrence	Combined Totals: Average % Bolis
Creeks	*Anguinella palmata*	10	43.5	29	*Anguinella palmata*	32	50.0	36
	Sesarma reticulatum	8	34.8	24	*Molgula* sp.	15	23.4	37
	Mytilidae	7	30.4	47	*Uca pugnax*	13	20.3	48
	Uca Pugnax	6	26.1	38	Decapoda	12	18.8	36
	Crassostrea virginica	6	26.1	37	*Crassostera virginica*	10	15.6	39
	Molgula sp.	6	26.1	30	*Chthamalus fragilis*	9	14.1	49
	Organic materials	4	17.4	55	*Sesarma reticulatum*	9	14.1	24
	Decapoda	3	13.0	57	Mytilidae	7	10.9	47
	Hydrozoa	2	8.7	80	Plant material	6	9.4	47
	Mollusca	2	8.7	25	Mollusca	6	9.4	20
Sounds	*Crassostrea virginica*	4	100.0	70	*Crassostrea virginica*	7	50.0	63
	Mytilidae	3	75.0	30	Mytilidae	4	28.6	23
	Cirripedia	1	25.0	5	Unidentified material	2	14.3	70
					Crustacea	2	14.3	55
					Bivalvia	2	14.3	50
					Spartina alterniflora	2	14.3	35
					Panopeus sp.	2	14.3	15
					Callineates sapidus	1	7.1	90
					Rhithropanopeus harrisii	1	7.1	60
					Sesarma cinereum	1	7.1	60
Beaches	NONE 1/	-	-	-	NONE	-	-	-
Offshore	NONE	-	-	-	*Chthamalus fragilis*	10	41.7	33
					Bivalvia	8	33.3	33
					Ascidiidae	6	25.0	42
					Ovalipes ocellatus	5	20.8	62
					Decapoda	5	20.8	24
					Unidentified material	5	20.8	22
					Portunus gibbesii	3	12.5	53
					Echinarachnius parma	3	12.5	27
					Tubificidae	3	12.5	23
					Crassostrea virginica	2	8.3	30
Totals	*Crassostrea virginica*	10	37.0	50	*Anguinella palmata*	33	32.4	35
	Mytilidae	10	37.0	42	*Crassostrea virginica*	19	18.6	47
	Anguinella palmata	10	37.0	29	*Chthamalus fragilis*	19	18.6	41
	Sesarma reticulatum	8	29.6	24	Decapoda	18	17.6	33
	Uca pugnax	6	22.2	38	*Molgula* sp.	15	14.7	37
	Molgula sp.	6	22.2	30	*Uca pugnax*	14	13.7	46
	Organic material	4	14.8	55	Unidentified material	12	11.8	43
	Decapoda	3	11.1	57	Mytilidae	12	11.8	38
	Hydrozoa	2	7.4	80	Bivalvia	10	9.8	37
	Mollusca	2	7.4	25	*Sesarma reticulatum*	10	9.8	24

1/ None denotes no specimens were collected with food in stomachs.

Table 133. Number and percent of sheepshead, *Archosargus probatocephalus*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	9	64.3	5	35.7	14	100.0	3	75.0	1	25.0	4	100.0	-	-	-	-	-	-
Spring	20	90.9	2	9.1	22	100.0	1	100.0	0	0.0	1	100.0	23	82.1	-	-	-	-
Summer	12	92.3	1	7.7	13	100.0	6	100.0	0	0.0	6	100.0	-	-	-	-	-	-
Fall	23	100.0	0	0.0	23	100.0	4	80.0	1	20.0	5	100.0	-	-	-	-	-	-
Total	64	88.9	8	11.1	72	100.0	14	87.5	2	12.5	16	100.0	-	-	-	-	-	-

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	-	-	-	-	-	-	12	66.7	6	33.3	18	100.0
Spring	23	82.1	5	17.9	28	100.0	44	86.3	7	13.7	51	100.0
Summer	1	100.0	0	0.0	1	100.0	19	95.0	1	5.0	20	100.0
Fall	-	-	-	-	-	-	27	96.4	1	3.6	28	100.0
Total	24	82.8	5	17.2	29	100.0	102	87.2	15	12.8	117	100.0

NOTE: A dash (-) denotes none collected.

sharply as only 66.7% of the stomachs contained food. This was probably due to a decrease in food supply as well as decreased metabolic rate.

Feeding activity appeared to vary little between sectors as over 82% of the stomachs contained food in each sector (Table 133). Although only a slight difference was observed, feeding activity was greatest in the creeks as 88.9% of the stomachs contained food.

Temperature apparently had little effect on feeding behavior at temperatures above 16°C as over 85% of the stomachs examined contained food. However, at temperatures below 15°C, the percentage dropped to 50%.

Little correlation between moon phase and feeding habits could be determined as so few specimens were collected. The percentages of stomachs containing food versus empty stomachs are presented by lunar phase in Table 51.

ATLANTIC CROAKER

The geographic distribution of the Atlantic croaker (*Micropogonias undulatus*) includes the northern and western parts of the Gulf of Mexico, along the Atlantic coast from south Florida to Massachusetts, the Greater Antilles, and along the South American Atlantic coast from Surinam to Argentina (Fischer, 1978).

Croaker generally prefer sandy hard rocky bottoms or shallow firm bottom areas adjacent to oyster reefs. However, larger croaker are more common in the deeper waters of channels in rivers and sounds during the summer and early fall months and move to offshore waters during colder months. Juveniles are common throughout the estuaries during the warmer months. However, larger juveniles (>50 mm) become scarce in inside waters during the colder months while smaller juveniles (<50 mm) become abundant in the upper portions of the estuaries during late fall.

Movement and Migration

From April 3, 1979 through June 28, 1982, 3,456 Atlantic croaker were tagged and released. Length frequencies of tagged croaker in 50 mm length groups are presented in Table 134. Lengths (TL) ranged from 130 to 358 mm for fish tagged with Howitt tags and 90 to 324 mm for those tagged with Floy tags. Length frequencies of croaker tagged with each tag type are presented in Table 135, and Table 136 lists the length frequencies in 20 mm groups by gear type used for capture.

Tagged croaker were returned from September 25, 1979 through September 26, 1982. Of 3,456 croaker tagged, 87 (2.5%) were recaptured and tags returned. Recovery rates, when separated into 50 mm length groups, ranged as high as 50%. However, this peak return rate represents only one recapture. The next highest return rate was 13.5% for croaker measuring 251-300 mm. The number of fish released and recaptured, time at large, and distance traveled are presented in Table 134. Time at large ranged from 2 to 416 days with an average of 63 days. Distance traveled ranged as far as 179 km, averaging 10.9 km.

The recovery rate for croaker tagged with Howitt tags was 4.2% as opposed to only 0.5% with Floy tags (Table 135). However, such return rate comparisons are misleading unless the sizes of tagged fish are considered. Approximately 77% of all croaker tagged with Floy tags were smaller than the minimum size recorded from recreational recaptures. In contrast, only 36% of those tagged with Howitt tags were smaller than the minimum length of recreational recoveries.

Recreational fishermen were the major source of recoveries, accounting for 50 (57.5%) of the 87 returns. Thirteen (14.9%) returns were by commercial fishermen, and study activities accounted for the remaining 24 (27.6%) recoveries (Table 11). Of 50 recreational recaptures, 27 (54%) included sufficient information to determine lengths of creel size fish. Recreational recapture lengths ranged from 167 to 330 mm with an average size of 253 mm (Table 12). Recapture lengths indicated that most creel size fish ranged from 200 to 300 mm with the greatest occurrence at 250-300 mm (Table 13).

The creeks produced 47.7% of all recaptures, with 58.5% of the recoveries from the creeks being taken during spring (Tables 14 and 15). The sounds produced 36.1% of all recoveries with most of the returns for

Table 134. Number tagged, number and percent recaptured, days at large and distance traveled for Atlantic croaker, *Micropogonias undulatus*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large Avg.	Days At Large Max.	Distance Traveled (km) 1/ Avg.	Distance Traveled (km) 1/ Max.
51 - 100	33	0	0.0				
101 - 150	892	4	0.4	33	65	13.9	19
151 - 200	1,908	27	1.4	83	416	16.1	113
201 - 250	406	27	6.7	55	191	13.0	179
251 - 300	207	28	13.5	57	187	3.7	28
301 - 350	8	0	0.0				
351 - 400	2	1	50.0	106	0		
Total	3,456	87	2.5	63	416	10.9	179

1/ Distance measured in kilometers from point of release to point of recapture.

Table 135. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for Atlantic croaker, *Micropogonias undulatus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
75				33			33		
125	46			846	4	0.5	892	4	0.4
175	1,274	24	1.9	638	3	0.5	1,908	27	1.4
225	374	27	7.2	30			405	27	6.7
275	203	28	13.8	2			206	28	13.6
325	7			1			8		
375	2	1	50.0				2	1	50.0
Total	1,908	80	4.2	1,546	7	0.5	3,454	87	2.5

NOTE: Number tagged and recaptured does not include the two fish tagged with both tag types.

Table 136. Number of Atlantic croaker, *Micropogonias undulatus*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Gill Net (in)[1/] 2	2-7/8	4-5/8	6	Trammel Net	Trawl	Cast Net	Trap	Hook/Line	Totals
90	-	-	-	-	-	33	-	-	-	33
110	-	-	-	-	-	382	-	-	-	382
130	-	-	-	-	-	320	-	-	1	321
150	1	-	-	-	-	540	-	-	2	543
170	16	10	-	-	17	910	-	-	21	974
190	21	15	-	-	32	471	1	-	41	581
210	4	13	-	-	34	141	1	-	22	215
230	1	28	2	-	9	37	-	1	32	110
250	7	95	-	-	10	36	-	-	19	167
270	1	53	-	1	7	15	-	-	7	84
290	1	28	1	1	4	1	-	-	-	36
310	-	4	-	-	1	2	-	-	-	7
330	-	-	-	-	-	-	-	-	1	1
350	-	2	-	-	-	-	-	-	-	2
Totals	52	248	3	2	114	2888	2	1	146	3456

[1/] Gill net sizes are stretch mesh measurements.

this sector during the summer (58.1%). The beaches and offshore waters each contributed 8.1% of the recoveries with most returns taken during fall (57.2%). In general, summer produced the highest number of returns and winter produced the lowest.

Georgia residents fishing in state waters accounted for 42 (84%) of the 50 recreational recaptures. Of these resident fishermen, 32 (76%) traveled 40 km or less to reach the location of fish recapture while approximately 90% traveled less than 120 km (Table 16).

Shrimp was the only reported bait used by recreational fishermen to recapture croaker. Approximately 84% of all croaker recaptures were caught by recreational fishermen using dead shrimp. Live shrimp accounted for the remainder (Table 17).

Approximately 50.6% of the recoveries were caught in the immediate area of release. Of 86 recoveries with sufficient information to ascertain movement, 79 (92%) were recaptured within 25 km of the release site. Four recoveries (4.7%) had moved 26 to 50 km, and three (3.5%) moved over 100 km (Table 137). Of three croakers traveling over 100 km, two moved southward (138 km) and were recaptured during May and August in the St. Johns River near Jacksonville, Florida. The third specimen moved northward (179 km) and was recaptured in May near Cane Island, South Carolina.

Spring was the season of greatest movement with an average distance of 15.8 km (Table 21). Movements during summer and fall were similar, averaging 9.1 and 8.2 km, respectively. Winter produced least movement, but this conclusion is based on a single return at large 105 days and caught in the area of release.

Approximately half (48%) of all recaptures were caught in the general area of release (Table 138). As indicated by the greater number of recaptures that moved in a creek to beach direction after tagging, there was greater movement out of the estuary. After emigrating from the estuaries, most croaker (82%) moved southward. Recovery data indicated that very few creel size croaker remain in the estuaries during winter.

Table 137. Days at large and distance traveled for Atlantic croaker, *Micropogonias undulatus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Days At Large	Distance Traveled (km)							Total	Percent
	0	0.1-1	1-5	6-25	26-50	51-100	101-200		
1 - 50	27	4	5	11	-	-	-	47	54.0
51 - 100	13	-	-	8	1	-	1	23	27.1
101 - 150	3	1	-	1	2	-	-	7	8.2
151 - 200	1	-	1	3	-	-	1	6	7.1
201 - 300	-	-	-	1	-	-	1	2	2.4
301 - 500	-	-	-	-	1	-	-	1	1.2
Total	44	5	6	24	4	-	3	86	100.0
Percent	50.6	5.9	7.1	28.2	4.7	-	3.5	100.0	

Table 138. Seasonal movement of Atlantic croaker, *Micropogonias undulatus*, tagged in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

		Direction Moved By Recaptured Tagged Fish				
		Caught In Area	Movement Within Estuary		Movement Out Of Estuary	
Season	Length Group (mm)	Of Release	Creek to Beach	Beach To Creek	North	South
Winter	101-150	-	-	-	-	-
	151-200	-	-	-	-	-
	201-250	-	-	-	-	-
	251-300	1	-	-	-	-
	Total	1	-	-	-	-
	Percent	100.0	-	-	-	-
Spring	101-150	-	1	-	-	-
	151-200	2	2	1	-	1
	201-250	11	1	-	1	1
	251-300	5	-	-	-	1
	Total	18	4	1	1	3
	Percent	66.7	14.8	3.7	3.7	11.1
Summer	101-150	-	1	1	1	-
	151-200	2	3	1	1	2
	201-250	5	-	-	-	2
	251-300	5	3	-	-	3
	Total	12	7	2	2	7
	Percent	40.0	23.3	6.7	6.7	23.3
Fall	101-150	-	-	-	-	-
	151-200	1	1	-	-	7
	201-250	1	-	-	-	-
	251-300	4	1	2	1	1
	Total	6	2	2	1	8
	Percent	31.6	10.5	10.5	5.3	42.1
Combined	Total	37	13	5	4	18
	Percent	48.0	16.9	6.5	5.2	23.4

Length-Weight Relationship

The length-weight relationship for 260 Atlantic croaker ranging from 84 to 389 mm and 7 to 765 g was $\log W = 3.195 \log L - 5.367$. The correlation coefficient value for length-weight for croaker was 0.9632 ($P < 0.0001$). Least-squares regression analyses on the length-weight relationships for male, female, and all Atlantic croaker combined are shown in Table 24. Figure 36 illustrates the length-weight relationship for Atlantic croaker. The greatest lengths recorded for male and female Georgia croaker were 291 and 389 mm, respectively. The heaviest specimens were 270 g for males and 765 g for females. Comparison of length-weight relationships for several populations of Atlantic croaker are shown in Table 139.

Age and Growth

Age and growth studies based on the scale technique have been validated as an ageing method for Atlantic croaker (Arnoldi, Herke, and Clairain, 1973; White and Chittenden, 1977; Barger and Johnson, 1980). Croaker generally appear to form two annulus-like marks per year. White and Chittenden (1977) described the characteristics of the two annulus-like scale markings used to determine the age of croaker. The first mark is a light mark formed in warm periods and characterized by only a few new circuli cutting over older incomplete circuli in the lateral field. However, the first mark has little or no differential spacing of circuli before or after the mark. The second mark is formed in cold periods and characterized by heavy cutting over of circuli and differential spacing of circuli in the lateral fields. The second scale mark was considered to be the true annulus and was the basis for ageing Atlantic croaker.

Scale samples from 272 Atlantic croaker ranging from 93 to 389 mm were examined and 248 (91%) were considered legible for age determinations. Otolith sections from these 248 fish were examined to document scale ring counts. Rings on otoliths formed simultaneously with the second scale mark described above. The first annulus-like mark on scales were indistinct and were often undetectable.

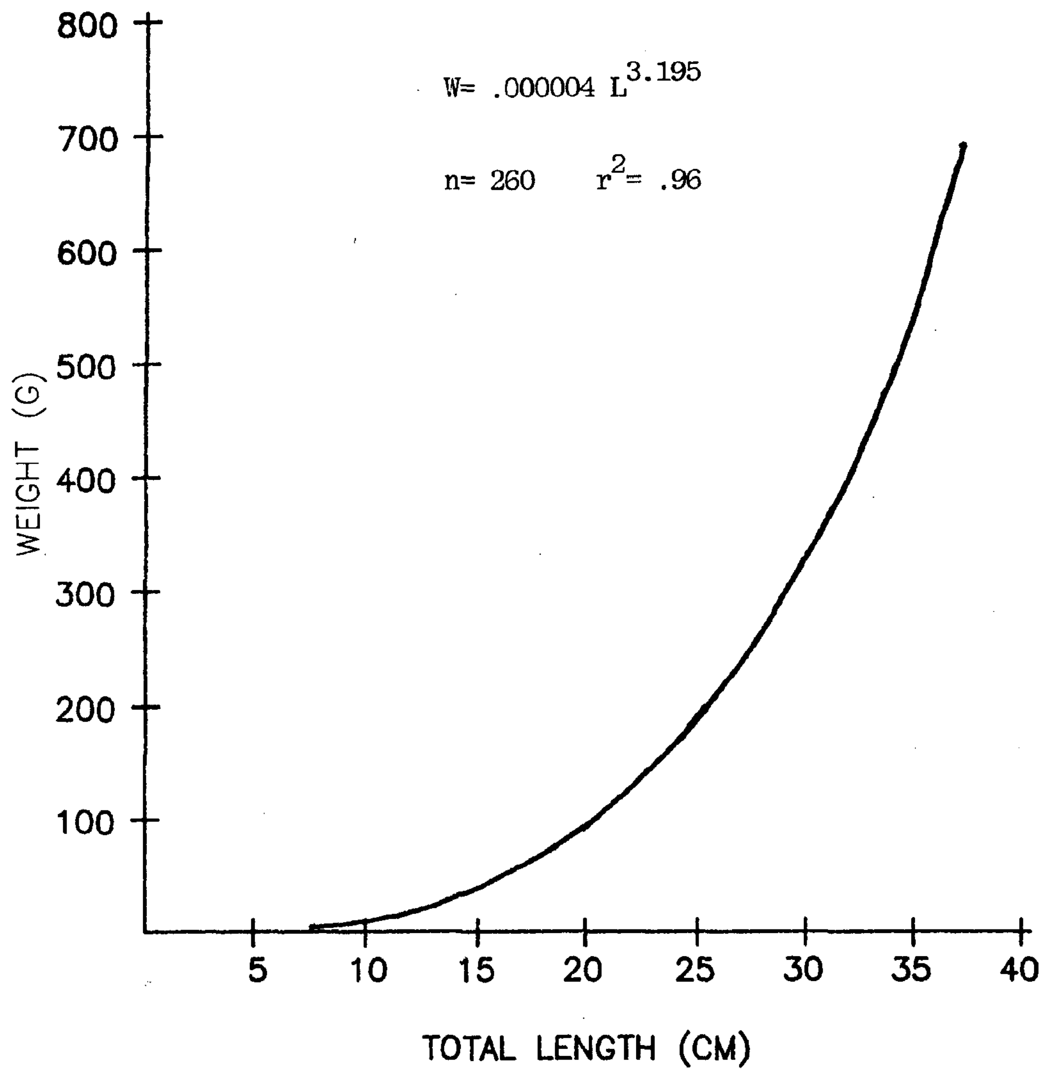

Figure 36. Length-weight relationship of Atlantic croaker, *Micropogonias undulatus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Table 139. Comparison of total length-weight relationships for several populations of Atlantic croaker, *Micropogonias undulatus*.

Study	Location	Length-Weight Equation	Weight of Fish (g)		
			100 mm	200 mm	300 mm
Dawson (1963)	Mississippi and Louisiana	log W = 3.148 logL -5.285	10	91	326
White and Chittenden (1977)	Texas and Louisiana	log W = 3.15 logL 5.26	11	97	349
Present Study	Georgia	log W = 3.195 logL -5.367	10	90	328

Calculation of mean monthly growth of marginal increments validated that scale annuli (second scale mark type) were formed only once annually. Annulus formation was detectable during March, April, and May.

Least-squares regression analyses on the relationship between fish length and scale radius were performed. An r^2 value of 0.87 ($P < 0.0001$) suggests back-calculations based on fish length/scale radius would be reliable for estimating fish length at time of annulus formation. Empirical and mean back-calculated total lengths at age for Atlantic croaker are presented in Table 140. Table 141 shows the empirical and weighted mean back-calculated lengths for juvenile, male, female, and all croaker combined. Figure 37 illustrates length-age relationships, and Table 142 shows the length-age equations for croaker.

Typically, the life span of croaker on both the Atlantic and Gulf coasts appears to be two years (White and Chittenden, 1976). Although older croaker are uncommon, five year old fish have been collected in the Gulf of Mexico (Barger and Johnson, 1980) and in Georgia (present study). The largest specimen collected during this study was 389 mm while the largest specimen reported by Mahood et al. (1974) was 443 mm. Mean lengths for one year old croaker from several populations ranged from 108 to 274 mm (Table 142). Weighted mean back-calculated lengths determined for one year old croaker in Georgia were fairly consistent with lengths reported from many areas. Furthermore, lengths of older Georgia croaker were similar to those reported in the Gulf (Barger and Johnson, 1980).

Maturity and Spawning

From the data collected during a previous three-year estuarine survey of Georgia's coastal waters it was concluded that the spawning season for croaker was August through November (Mahood et al., 1974). It was also reported that juvenile croaker were found throughout Georgia's estuaries in all months with peak abundance from May through September. The data collected during this study, however, indicate that croaker spawning activity probably extends from as early as August to as late

Table 140. Mean back-calculated total lengths for Atlantic croaker, *Micropogonias undulatus*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back-Calculated Lengths of Successive Scale Rings				
				1	2	3	4	5
0	137	92 - 249	148					
1	82	160 - 318	248	169				
2	27	213 - 336	268	149	233			
3	1	297	297	161	214	263		
4	0							
5	1	389	389	183	270	316	346	362
	Weighted Means			164	233	290	346	362
	Growth Increment			164	69	57	56	16

NOTE: Lengths measured in millimeters.

Table 141. Number, empirical and back-calculated total lengths, and growth increments by sex and age for Atlantic croaker, *Micropogonias undulatus*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Sex	Age 1	2	3	4	5
Juveniles					
Number	5	1			
Mean Length at Capture	226	240			
Back-Calculated Length	170	233			
Growth Increment	170	63			
Males					
Number	16	9			
Mean Length at Capture	249	253			
Back-Calculated Length	161	225			
Growth Increment	161	64			
Females					
Number	61	17	1	0	1
Mean Length at Capture	250	278	297		389
Back-Calculated Length	164	237	290	346	361
Growth Increment	164	73	53	56	15
Combined					
Number	82	27	1	0	1
Mean Length at Capture	248	268	297		389
Back-Calculated Length	164	233	290	346	361
Growth Increment	164	69	57	56	15

NOTE: Lengths measured in millimeters.

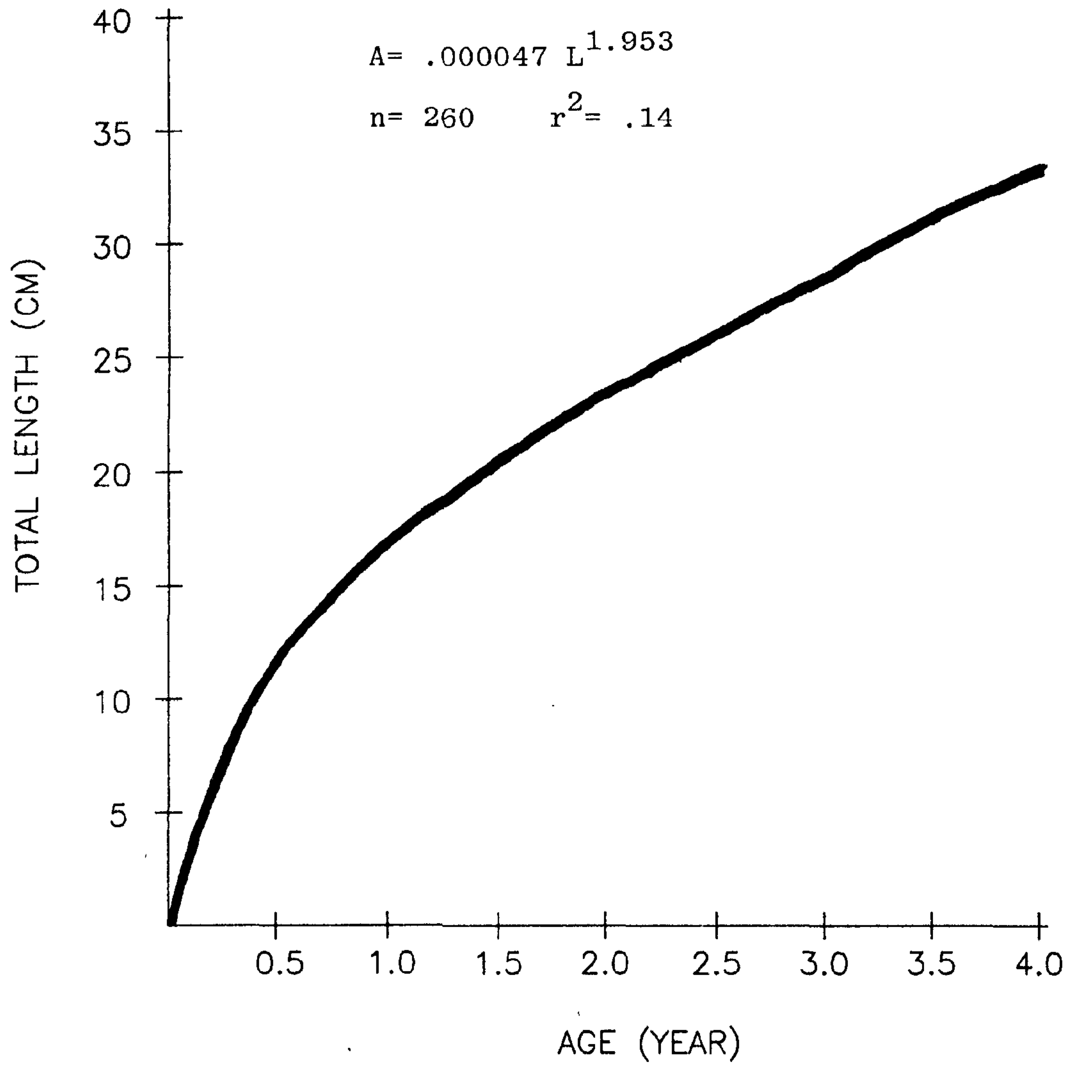

Figure 37. Length-age relationship of Atlantic croaker, *Micropogonias undulatus*, collected in Glynn County, Georgia.

Table 142. Comparison of lengths at age for several populations of Atlantic croaker, *Micropogonias undulatus*.

Study	Location	Length at Age (mm) I	II	III	IV	V
Welsh and Breder (1924)	New Jersey	150				
Pearson (1929)	Texas	150				
Hildebrand and Cable (1930)	North Carolina	143				
Haven (1957)	Virginia	175-180				
Hansen (1970)	Florida: 1964	108				
	1965	130				
Herke (1971)	Louisiana	274*				
Aronoldi (1973)	Louisiana	235*				
White and Chittenden (1976)	Texas and Louisiana	181	270			
Barger and Johnson (1980)	Gulf of Mexico	169	224	268	305	337
Present Study	Georgia	164	233	290	346	361

NOTE: An asterisk (*) denotes converted from standard length to total length using the formula TL = 1.37 SL.

as April, with peak activity in September and October as advanced stages (stages IV through VII) were collected from inside waters during these two months (Table 143). This study had limited utilization of trawls in ocean waters which resulted in limited collection of adult croaker in spawning condition. It is generally agreed by other investigators that most spawning takes place at the entrance of bays and at sea.

Our data appear to agree with that of Hildebrand and Cable (1930) in that spawning activity may last as long as nine months, peaking in September and October. They also agree with Bearden (1964) in that most spawning activity probably takes place in offshore waters. Lunz (1955) reported that spawning in South Carolina takes place in offshore waters beyond the limits of normal shrimping operations. This probably explains why very few advanced stages of gonadal development are taken from Georgia's inshore waters.

Since our sampling technique utilized primarily gillnets in the inside waters from the beaches to the creeks, sampling design limited the collection of adult croaker. Advanced maturity stages were collected only during September, October, and March and were not found at salinities below 16 $^{o}/oo$ (Table 144). Advanced maturity stages were collected only from temperatures below 28^{o}C and salinities higher than 16 $^{o}/oo$ (Table 145). These specimens came from the mouth of Dubignion Creek on the north end of Jekyll Island near the seaward end of St. Simons Sound.

One postlarval croaker was collected in ichthyoplankton samples from the beach in January (Table 63). However, plankton samples were contracted for identification only during the 5-month period from January through May. Young croaker were collected in trawl samples during all seasons with an increasingly higher occurrence rate from the low in summer to the peak during spring (Table 52). They were also collected in all sectors, but were most abundant in the creeks and rivers (Table 53).

The smallest specimens for which sex was determined through gross examination were 108 mm for females and 110 mm for males. These fish were age 0, or in the first year of life. The smallest female exhibiting developing ovaries (stage III or greater) was a 182 mm specimen

Table 143. Number of Atlantic croaker, *Micropogonias undulatus*, collected by month, sex and reproductive stage for the period January 1979 through June 1982.

	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
Month	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	2	0												
February	1	0												
March	3	7							1	0				
April	2	1												
May	5	2												
June	8	1												
July	36	15												
August	21	2	1	0										
September	15	4	13	0	6	0			2	0				
October	0	1	1	1	2	0	2	0						
November	1	0												
December	5	1												

Table 144. Stages of gonadal development for Atlantic croaker, *Micropogonias undulatus*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

		Surface Water Salinity (0/00)																	
	Reproductive	0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		Totals	
Month	Stage	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	I	-	-	-	-	-	-	-	-	-	-	1	0	1	0	-	-	2	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I	-	-	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I	-	-	-	-	-	-	3	4	0	3	-	-	-	-	-	-	3	7
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	-	-	1	0	-	-	-	-	1	0	0	1	-	-	-	-	2	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	I	-	-	-	-	-	-	2	0	1	1	2	1	-	-	-	-	5	2
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	I	-	-	-	-	-	-	1	0	5	1	2	0	-	-	-	-	8	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
July	I	-	-	-	-	4	1	2	1	5	2	19	8	6	2	-	-	36	14
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	I	-	-	-	-	-	-	1	0	7	0	9	2	4	0	-	-	21	2
	II	-	-	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I	-	-	-	-	-	-	5	2	1	1	7	1	2	0	-	-	15	4
	II	-	-	-	-	-	-	4	0	-	-	8	0	1	0	-	-	13	0
	III	-	-	-	-	-	-	2	0	3	0	-	-	1	0	-	-	6	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	1	0	1	0	-	-	-	-	-	-	2	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I	-	-	-	-	-	-	-	-	0	1	-	-	-	-	-	-	0	1
	II	-	-	-	-	-	-	-	-	0	1	1	0	-	-	-	-	1	1
	III	-	-	-	-	-	-	2	0	-	-	-	-	-	-	-	-	2	0
	IV	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	V-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I	-	-	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I	-	-	-	-	-	-	-	-	1	1	4	0	-	-	-	-	5	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combined Total	I	-	-	1	0	4	1	17	6	21	11	44	13	13	2	-	-	100	33
	II	-	-	-	-	-	-	5	0	0	1	9	0	1	0	-	-	15	1
	III	-	-	-	-	-	-	4	0	3	0	-	-	1	0	-	-	8	0
	IV	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	V	-	-	-	-	-	-	1	1	1	0	-	-	-	-	-	-	2	1
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 145. Stages of gonadal development for Atlantic croaker, *Micropogonias undulatus*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)	Reproductive Stage	Surface Water Temperature (°C) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	Totals F	Totals M
6-10	I	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-15	I	-	-	-	-	-	-	-	-	-	-	-	-	4	1	4	1
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-20	I	-	-	-	-	1	0	1	0	5	4	8	3	1	0	16	7
	II	-	-	-	-	-	-	-	-	0	0	4	0	1	0	5	0
	III	-	-	-	-	-	-	-	-	2	0	2	0	-	-	4	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	1	0	1	0	-	-	-	-	2	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-25	I	-	-	-	-	1	1	1	3	1	0	18	6	-	-	21	10
	II	-	-	-	-	-	-	-	-	0	1	-	-	-	-	0	1
	III	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-30	I	-	-	-	-	5	0	-	-	1	2	17	7	21	4	44	13
	II	-	-	-	-	-	-	-	-	1	0	8	0	-	-	9	0
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	2	0	-	-	2	0
	V-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-35	I	-	-	-	-	1	0	-	-	-	-	6	1	6	1	13	2
	II	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	III	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	I	-	-	-	-	8	1	2	3	8	6	49	17	32	6	99	33
	II	-	-	-	-	-	-	-	-	1	1	13	0	1	0	15	1
	III	-	-	-	-	-	-	-	-	2	0	4	0	-	-	6	0
	IV	-	-	-	-	-	-	-	-	-	-	2	0	-	-	2	0
	V	-	-	-	-	-	-	1	0	2	0	-	-	-	-	3	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(age 0). No advanced stages of development were observed in males, and the smallest stage II male was a 255 mm specimen (age I).

Bearden (1964) reported collecting 23 sexually mature South Carolina croaker over 166 mm in September, and several appeared ready to spawn. He reported that females over 178 mm were ripe or nearly so and males over 137 mm had running milt. Lassuy (1983), reporting from the literature, stated that maturity is reached at the end of the second year, but some fish may spawn before their second year. Wallace (1940) reported that croaker reach maturity at 240 mm for males and 275 mm for females or at age two and three years, respectively. Suttkus (1955) reported first spawning at the end of the second year of life. Hansen (1970) reported that croaker may spawn in their first year of life near Pensacola, Florida. White and Chittenden (1977) found that Texas croaker start to mature at about 140-170 mm TL.

The five female croaker exhibiting advanced gonadal development were collected three days prior to first quarter, three days prior to last quarter, and during a split phase of lunar activity (Table 40). These phases were all during periods of neap tides or low tidal amplitude. However, since only five specimens were collected, no conclusions can be drawn between lunar phases and spawning activity.

Females outnumbered males 3.7:1 (Table 41), and dominated at all salinity levels with over 66.7% of the catch at each level (Table 144).

As shown in Table 40, Atlantic croaker exhibiting advanced reproductive stages were virtually absent in collections made in Georgia estuaries, prohibiting the determination of fecundity for this species. However, fecundity was reported by Hansen (1970) to be approximately 41,200 eggs for 18 west Florida croaker. Hansen further reported these fish (101-145 mm SL) to be near the end of the first year of life.

Food Preference and Feeding Habits

Of 267 Atlantic croaker examined to determine food preferences and feeding habits, 236 (88.4%) contained food and 31 (11.6%) were empty. Food items identified in stomachs from fish grouped in 100 mm length groups are presented in Table 146. Juvenile croaker <100 mm

Table 146. Stomach contents of Atlantic croaker, *Micropogonias undulatus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group (mm) 1-100	101-200	201-300	301-400	Combined	Percent Occurrence	Average %Bolus
PISCES							
Pisces (unidentifiable)	1	23	13		37	21.6	51
Fundulus heteroclitus			1		1	0.4	90
Gobioides broussonetii			1		1	0.4	90
Ophichthus ophis			1		1	0.4	60
Opsanus tau			1		1	0.4	60
Symphurus plagiusa		1			1	0.4	60
ARTHROPODA							
Crustacea (unidentifiable)	2	53	14		69	29.2	36
Ampelisca abdita	1				1	0.4	<5
Amphipoda	1	8			9	3.8	16
Acetes americanus		4			4	1.7	35
Alpheus heterochelis		3	9	2	14	5.9	66
Anthuridae		1			1	0.4	20
Callianassa atlantica			1		1	0.4	80
Callinectes sapidus			2		2	0.8	50
Corophiidae		1			1	0.4	10
Cyathura polita		2	6		8	3.4	69
Decapoda	1	14	11	1	27	11.4	46
Eurypanopeus depressus		1	2		3	1.3	57
Diptera			1		1	0.4	20
Insecta			1		1	0.4	10
Melita nitida		1			1	0.4	10
Mysidae			1		1	0.4	10
Ogyrides alphaerostris		4			4	1.7	35
Palaemonetes sp.		1	2		3	1.3	43
Panopeus herbstii			5		5	2.1	60
Penaeidae		1	2		3	1.3	63
Penaeus duorarum			1		1	0.4	90
Penaeus setiferus			1		1	0.4	90
Portunus gibbesii		1	1		2	0.8	55
Sesarma cinereum			2		2	0.8	20
Sesarma reticulatum			1		1	0.4	60
Squilla empusa		5	2		7	3.0	83
Trachypeneus constrictus	1	3	1		5	2.1	66
Uca pugilator			5		5	2.1	80
Uca pugnax			3		3	1.3	67

Table 146. (continued)

Food Item	Length Group (mm) 1-100	101-200	201-300	301-400	Combined	Percent Occurrence	Average %Bolus
MOLLUSCA							
Mollusca (unidentifiable)		4	10	1	15	6.4	58
Brachidontes recurvus			1		1	0.4	50
Crassostrea viginica		1	1		2	0.8	15
CEPHALOPODA							
Lolliguncula brevis		1	2		3	1.3	23
ANNELIDA and ASCHELMENTHES							
Glyceridae			2		2	0.8	30
Nematoda	1	2			3	1.3	17
Nereidae		1	3		4	1.7	30
Nicolea simplex		47	35		82	34.7	51
Orbiniidae			1		1	0.4	<5
Rhynchocoela		1			1	0.4	50
Sabellidae	1				1	0.4	<5
Spionidae	1	1	1		3	1.3	30
Tubificidae		1			1	0.4	40
PLANT							
Detritus		26	16		42	17.8	42
Spartina alterniflora	2	35	4		41	17.4	45
INORGANIC MATERIAL	2	17	7		26	11.4	70
UROCHORDATA							
Molgula sp.			1		1	0.4	40
Molgula manhattensis			1		1	0.4	90
BRYOZOA							
Anguinella palmata			1		1	0.4	10
ANIMAL TISSUE		2			2	0.4	90

Number of stomachs: 267
Number and percent of stomachs containing food: 236 (88.4%)
Number and percent of empty stomachs: 31 (11.6)

fed mainly on crustaceans and annelid worms, but no single food item dominated as the preferred food. In specimens 101-300 mm annelid worms, mainly polychaetes, were the dominant food. The most frequently occurring species was the polychaete, *Nicolea simplex*. There was some inclusion of fish in the diet of specimens over 101 mm, but the only fish identified to species level was a tonguefish, *Symphurus plagiusa*. A limited sample of large croaker (>301 mm) were collected, but snapping shrimp, crabs, and mollusks were found in stomach contents.

Pearson (1929) reported that smaller Texas croaker fed mainly on annelids, particularly polychaetes, but no crabs and mollusks. However, in larger fish, shrimp were the main item, followed by annelids, fish, crabs, mollusks and other mixed diet. Chao and Musick (1977) found polychaetes and crustaceans as the main food items in the York River in Virginia. Stickney et al. (1975) suggested an opportunistic feeding pattern for Georgia croaker, with the most commonly ingested food items being mysid shrimp and polychaetes.

The 10 most frequently occurring food items in croaker stomachs are presented by season and sector in Table 147. Major foods consumed were annelid worms which occurred in 34.7% of the stomachs. However, crustaceans were also consumed in fairly large quantities (29.2%). Fish and fish parts were found in 15.7% while mollusks occurred in only 4.7%. Plant materials were observed in many stomachs, but were probably ingested incidentally as a result of the croaker's bottom feeding habits.

There was significant variation in food preferences from season to season. Snapping shrimp were the dominant food item during winter, but annelid worms and bivalve mollusks were also ingested (Table 147). In spring, the major food source was crustaceans which occurred in 45.1% of stomachs containing food. Annelid worms and fish parts were also major foods with each comprising 26.8%. Smooth cordgrass (*Spartina alterniflora*) was observed in over half the stomachs, but ingestion of this and other plant materials was probably more a result of incidental ingestion rather than directed feeding effort. During summer, annelids and crustaceans were the major food components, occurring in 46.1% and

Table 147. The 10 most frequently occurring food items found in the stomachs of Atlantic croaker, *Micropogonias undulatus*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Sector	Winter Food Item	Winter No. Stomachs	Winter Percent Occurrence	Winter Average % Bolus	Spring Food Item	Spring No. Stomachs	Spring Percent Occurrence	Spring Average % Bolus	Summer Food Item	Summer No. Stomachs	Summer Percent Occurrence	Summer Average % Bolus
Creeks	*Alpheus* sp.	4	57.1	88	Annelida	6	54.5	63	Annelida	18	36.0	49
	Bivalvia	2	28.6	90	Pisces	2	18.2	70	Organic material	12	24.0	27
	Annelida	1	14.3	90	*Spartina alterniflora*	2	18.2	30	Decapoda	9	18.0	48
	Plant detritus	1	14.3	20	Bivalvia	2	18.2	25	Crustacea	7	14.0	36
					Squilla empusa	1	9.1	90	Mollusca	6	12.0	43
					Opsanus tau	1	9.1	60	*Uca pugilator*	5	10.0	80
					Unidentified material	1	9.1	60	*Alpheus* sp.	5	10.0	46
					Mysidae	1	9.1	50	*Oyatnura polita*	4	8.0	83
					Plant detritus	1	9.1	40	Unidentified material	4	8.0	65
					Crustacea	1	9.1	40	*Panopeus* sp.	2	4.0	70
Sounds	Unidentified material	3	25.0	83	*Spartina alterniflora*	35	59.3	45	Annelida	35	54.7	46
	Annelida	3	25.0	37	Crustacea	33	55.9	34	Crustacea	22	34.4	30
	Pisces	2	16.7	90	Pisces	16	27.1	53	Organic material	22	34.4	30
	Crustacea	1	8.3	90	Annelida	13	22.0	50	Pisces	7	10.3	34
	Palaemonetes sp.	1	8.3	30	Decapoda	10	6.9	32	Unidentified material	7	10.3	30
	Decapoda	1	8.3	90	Amphipoda	7	11.9	17	Decapoda	5	7.8	62
	Organic material	1	8.3	90	Unidentified material	4	6.8	90	*Squilla empusa*	3	4.7	77
	Animal tissue	1	8.3	90	*Squilla empusa*	3	5.1	87	*Spartina alterniflora*	3	4.7	63
	Plant detritus	1	8.3	80	Nematoda	3	5.1	17	*Alpheus* sp.	2	3.1	80
	Tubificidae	1	8.3	40	Inorganic material	1	1.7	90	Inorganic materials	2	3.1	50
Beaches					Pisces	1	100.0	100	Unidentified material	1	100.0	100
Offshore	NONE [1]	-	-	-	NONE	-	-	-	NONE	-	-	-
Totals	*Alpheus* sp.	4	21.1	88	*Spartina alterniflora*	37	52.1	44	Annelida	53	46.1	47
	Annelida	4	21.1	50	Crustacea	32	45.1	34	Plant material	34	29.6	29
	Unidentified material	3	15.8	83	Pisces	19	26.8	57	Crustacea	29	25.2	32
	Bivalvia	2	10.5	90	Annelida	19	26.8	54	Decapoda	14	12.2	53
	Pisces	2	10.5	90	Decapoda	10	14.1	32	Unidentified material	12	10.4	40
	Plant detritus	2	10.5	50	Amphipoda	7	9.9	17	Pisces	9	7.8	28
	Crustacea	1	5.3	90	Unidentified material	5	7.0	84	*Alpheus* sp.	7	6.1	56
	Plant material	1	5.3	90	*Squilla empusa*	4	5.6	88	Mollusca	7	6.1	44
	Palaemonetes sp.	1	5.3	90	*Acetes americanus*	4	5.6	35	*Uca pugilator*	5	4.3	80
	Decapoda	1	5.3	90	Nematoda	3	4.2	17	*Oyatnura polita*	4	3.5	83

[1] NONE denotes no specimens were collected with food in stomachs.

Table 147. (continued)

Sector	Fall: Food Item	Fall: No. Stomachs	Fall: Percent Occurence	Fall: Average % Bolus	Combined Totals: Food Item	Combined Totals: No. Stomachs	Combined Totals: Percent Occurrence	Combined Totals: Average % Bolus
Creeks	Annelida	4	40.0	90	Annelida	29	37.2	59
	Crustacea	2	20.0	50	Plant material	12	15.4	27
	Pisces	2	20.0	30	*Alpheus* sp.	10	12.8	67
	Alpheus sp.	1	10.0	90	Crustacea	10	12.8	39
	Mollusca	1	10.0	90	Decapoda	9	11.5	48
	Spionidae	1	10.0	90	Mollusca	7	9.0	50
	Unidentified material	1	10.0	80	Unidentified material	6	7.7	67
	Trachypeneus constrictus	1	10.0	50	Pisces	6	7.7	35
	Cyathura polita	1	10.0	20	*Uca pugilator*	5	6.4	80
	Ogyrides alphaerostris	1	10.0	10	*Cyathura polita*	5	6.4	70
Sounds	Pisces	5	25.0	64	Crustacea	59	38.1	35
	Crustacea	5	25.0	54	Annelida	53	34.2	46
	Cyathura polita	3	15.0	67	*Spartina alterniflora*	38	24.5	47
	Trachypeneus constrictus	2	10.0	90	Pisces	30	19.4	53
	Decapoda	2	10.0	50	Plant material	25	16.1	34
	Annelida	2	10.0	40	Decapoda	18	11.6	46
	Ogyrides alphaerostris	1	5.0	90	Unidentified material	14	9.1	59
	Alpheus sp.	1	5.0	90	Amphipoda	9	5.8	16
	Penaeidae	1	5.0	90	*Squilla empusa*	6	3.9	82
	Eurypanopeus depressus	1	5.0	90	*Alpheus* sp.	4	2.6	65
Beaches	Mollusca	1	100.0	100	Pisces	1	33.3	90
					Mollusca	1	33.3	90
					Unidentified material	1	33.3	10
Offshore	NONE[1/]	-	-	-	NONE	-	-	-
Totals	Pisces	7	22.6	54	Annelida	82	34.7	51
	Crustacea	7	22.6	53	Crustacea	69	29.2	36
	Annelida	6	19.4	73	*Spartina alterniflora*	41	17.4	45
	Cyathura polita	4	12.9	55	Pisces	37	15.7	51
	Trachypeneus constrictus	3	9.7	77	Plant material	37	15.7	31
	Alpheus sp.	2	6.5	90	Decapoda	27	11.4	46
	Ogyrides alphaerostris	2	6.5	50	Unidentified material	21	8.9	59
	Eurypanopeus depressus	1	3.2	90	*Alpheus* sp.	14	5.9	66
	Penaeidae	1	3.2	90	Mollusca	11	4.7	46
	Callianassa atlantica	1	3.2	80	Amphipoda	9	3.8	16

1/ None denotes no specimens were collected with food in stomachs.

25.2% of the stomachs, respectively. Plant materials were found in 29.6% of summer stomachs. The most frequently ingested crustaceans during summer were snapping shrimp (*Alpheus* sp.) and sand fiddler crabs (*Uca pugilator*). Although crustaceans were the primary food source during fall, fish were ingested more frequently than at any other time of the year as 22.6% of the stomachs contained fish and fish parts. Annelids were ingested less frequently than fish during fall. The slender isopod (*Cyathura polita*) and the small penaeid shrimp (*Trachypeneus constrictus*) were the major crustaceans observed in the fall diet.

Stickney et al. (1977) found that the main food items in their study in and near Georgia were harpactocoid copepods during spring and calanoid copepods in summer. During fall the major foods were polychaetes, mysid shrimp, and other crustaceans. In winter harpactocoid copepods were again dominant. In smaller specimens (less than 39 mm SL) they found that harpactocoid copepods were numerically dominant and were present along with calanoid copepods in all length groups of fish up to 99 mm SL. In fish above 99 mm SL the major foods were crustaceans and polychaetes. They also noted that relatively larger amounts of other organisms were ingested as croaker grew and that larger specimens may have grown too large to feed efficiently on smaller copepods. Fish were also found in increasing frequency with increasing size in larger specimens.

Although major food sources were the same, there was some difference in ingestion rates between sectors. In the creeks, annelid worms and crustaceans were the major food items. Annelids were found in 37.2% of the stomachs containing food, but the snapping shrimp was the most frequently identified individual food item. Mollusks were found in relatively few stomachs (9.0%) and none were identified to species.

In the sounds the two major food groups were crustaceans (38.1%) and annelids (34.2%). Fish and fish parts occurred in 19.4% while mollusks were not included in the top 10 items. Mantis shrimp (*Squilla empusa*) and snapping shrimp (*Alpheus* sp.) were the most frequently ingested species.

Too few specimens were collected from the beaches and offshore waters to determine food preferences in these sectors.

Feeding activity, as related to the number of stomachs containing food, was greatest during spring as 94.7% of the stomachs contained food (Table 148). During summer and fall feeding activity was equal at 86%, while in winter there was a very slight decline to 82.6%. These high percentages indicate that croaker are active feeders throughout the year. Variations are probably a result of food availability rather than feeding activity.

There was a slightly higher percentage of stomachs containing food in the sounds (90.6%) than in the creeks (85.7%) (Table 148). Too few specimens were collected from the beaches and offshore waters to draw conclusions for these sectors.

Croaker were active feeders at all temperature ranges as over 86.2% of the stomachs collected from each temperature range contained food (Table 50).

Peak feeding activity according to lunar phase occurred during the week preceding first quarter through the three days immediately thereafter, and during the week leading up to last quarter when over 86.8% of the stomachs contained food (Table 51). Feeding activity declined slightly during the three day period before new and full moon phases when the percentage dropped to 80%.

SPOT

Spot (*Leiostomus xanthurus*) are geographically distributed in the Gulf of Mexico from the Rio Grande to south Florida, and on the Atlantic coast from south Florida to Massachusetts (Fischer, 1978). They are commonly found in habitats similar to that of Atlantic croaker, but spot also prefer softer substrates than do croaker. In general, they may be found in concentrations over almost all smooth bottom habitats within the estuaries, and are one of the most widely distributed fish in our estuaries. Spot generally move offshore during colder months, but both adults and juveniles may be found in estuarine waters year round.

Table 148. Number and percent of Atlantic croaker, *Micropogonias undulatus*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	7	77.8	2	22.2	9	100.0	12	92.3	1	7.7	13	100.0	-	-	-	-	-	-
Spring	11	84.6	2	15.4	13	100.0	59	96.7	2	3.3	61	100.0	1	100.0	0	0.0	1	100.0
Summer	50	90.9	5	9.1	55	100.0	64	84.2	12	15.8	76	100.0	1	50.0	1	50.0	2	100.0
Fall	10	71.4	4	28.6	14	100.0	20	95.2	1	4.8	21	100.0	1	100.0	0	0.0	1	100.0
Total	78	85.7	13	14.3	91	100.0	155	90.6	16	9.4	171	100.0	3	75.0	1	25.0	4	100.0

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	0	0.0	1	100.0	1	100.0	19	82.6	4	17.4	23	100.0
Spring	-	-	-	-	-	-	71	94.7	4	5.3	75	100.0
Summer	-	-	-	-	-	-	115	86.5	18	13.5	133	100.0
Fall	-	-	-	-	-	-	31	86.1	5	13.9	36	100.0
Total	0	0.0	1	100.0	1	100.0	236	88.4	31	11.6	267	100.0

Movement and Migration

From February 13, 1979 through June 23, 1981, 793 spot were tagged and released. Length frequencies of tagged spot in 50 mm length groups are included in Table 149. Lengths(TL) of spot tagged with Howitt tags ranged from 142 to 326 mm, and those tagged with Floy tags ranged from 108 to 249 mm. Length frequencies of spot tagged with each tag type are shown in Table 150. Table 151 lists the length frequencies of tagged spot in 20 mm groups by gear type used for capture.

Tagged spot were returned from September 8, 1979 through July 6, 1981. Of 793 tagged, 13 (1.6%) were recaptured and tags returned. Recovery rates, when separated into 50 mm length groups, ranged no higher than 2.1%. The number of spot released and recaptured, time at large, and distance traveled are presented in Table 149. Time at large ranged from 6 to 88 days with an average of 38 days. Distance traveled ranged as far as 118 km with an average of 14.2 km.

The overall recovery rate for spot tagged with Howitt tags was 1.7% and with Floy tags was 1.6% (Table 150). Recovery rates, when separated into 50 mm length groups, ranged as high as 1.9% with Howitt tags and 2.1% with Floy.

Commercial fishermen were the major source of recoveries, accounting for 8 (61.5%) of 13 returns. Only 1 (7.7%) return was by a recreational fisherman. Study activities accounted for the remaining four (30.8%) recoveries (Table 11). Recapture length was not obtained for the recreational recapture. Recapture lengths from recoveries by commercial fishermen and project personnel using commercial gear ranged from 152 to 226 mm.

Sufficient information was obtained on 11 (85%) of the 13 recaptures to determine the estuarine sector and season of capture. Comparison of return rates between the four sectors revealed that the offshore waters produced the highest return rate (Table 14). Two commercial recaptures did not include location of recapture, but these were probably caught offshore as commercial trawling was legal only in offshore waters. If this assumption is true, it would increase the percentage of recaptures

Table 149. Number tagged number and percent recaptured, days at large and distance traveled for spot, *Leiostomus xanthurus*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large		Distance Traveled (km) 1/	
				Avg.	Max.	Avg.	Max.
101 - 150	154	2	1.3	52	56	44.7	47
151 - 200	380	8	2.1	37	88	12.2	34
201 - 250	250	3	1.2	33	47	39.3	118
251 - 300	8	0	0.0				
Total	793	13	1.6	38	88	23.4	118

1/ Distance measured in kilometers from point of release to point of recapture.

Table 150. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for spot, *Leiostomus xanthurus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
125	6			148	2	1.4	154	2	1.3
175	53	1	1.9	327	7	2.1	380	8	2.1
225	163	3	1.8	87			250	3	1.2
275	8						8		
325	1						1		
Total	231	4	1.7	562	9	1.6	793	13	1.6

Table 151. Number of spot, *Leiostomus xanthurus*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Gill Net (in)[1/] 2	Gill Net 2-7/8	Gill Net 3-1/2	Gill Net 4-5/8	Trammel Net	Seine	Trawl	Trap	Hook/ Line	Totals
110	-	-	-	-	-	-	3	1	-	4
130	-	-	-	-	-	-	57	-	-	57
150	-	-	-	-	-	-	229	-	1	230
170	2	-	-	-	1	1	149	-	-	153
190	14	18	-	1	-	-	57	-	-	90
210	20	104	1	-	1	-	26	-	-	152
230	4	74	-	-	2	-	3	2	-	85
250	-	18	-	-	2	-	-	-	-	20
270	-	1	-	-	-	-	-	-	-	1
290	-	-	-	-	-	-	-	-	-	-
310	-	-	-	-	-	-	-	-	-	-
330	-	1	-	-	-	-	-	-	-	1
Totals	40	216	1	1	6	1	524	3	1	793

[1/] Gill net sizes are stretch mesh measurements.

from offshore waters to 54%. Creek and sound sectors produced 4 (36.4%) and 2 (18.2%) of the 11 recoveries, respectively. No recoveries were caught in the beach sector. Spring produced the highest return rate with 63.6% of all recoveries (Table 15).

Of the 11 spot recoveries, three (27%) were caught in the immediate area of release; eight (73%) were caught within 25 km; two (18.2%) had moved from 26 to 50 km; and one (9.1%) had traveled over 100 km (Table 152). The spot that traveled over 100 km was tagged in September and recaptured in November offshore from Jacksonville, Florida -- a distance of 118 km. As observed in Table 153, the number of recoveries was insufficient to ascertain movement trends within the estuary.

Length-Weight Relationship

The length-weight relationship for 325 spot, ranging from 120 to 283 mm and 23 to 276 g, was $\log W = 3.121 \log L - 5.096$. The correlation coefficient value for length-weight for spot was 0.8973 ($P < 0.0001$). Least-squares regression analyses on the length-weight relationships for male, female, and all spot combined are presented in Table 24. Figure 38 illustrates length-weight relationship for spot. The greatest lengths recorded for male and female Georgia spot were 283 and 263 mm, respectively. The heaviest male and female weighed 276 and 293 g, respectively. Comparison of length-weight relationships for several spot populations are shown in Table 154.

Age and Growth

Based on a literature review, Barger and Williams (1980) reported that the most frequently applied method for age determination of spot was length-frequency analyses. However, such analyses identified only two age classes. Based on the scale technique, Welsh and Breder (1924) and Pacheco (1962) reported collection of age IV spot in New Jersey and Chesapeake Bay, respectively.

Sundararaj (1960) and Pacheco (1962) presented evidence validating the use of scales for age determination of spot in Louisiana and lower Chesapeake Bay, respectively. However, due to faintness of the annual

Table 152. Days at large and distance traveled for spot, *Leiostomus xanthurus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Days At	Distance Traveled (km)								
Large	0	0.1-1	1-5	6-25	26-50	51-100	101-200	Total	Percent
1 - 50	2	-	1	2	2	-	1	8	72.7
51 - 100	1	-	-	2	-	-	-	3	27.3
Total	3	-	1	4	2	-	1	11	100.0
Percent	27.3	-	9.1	36.3	18.2	-	9.1	100.0	

NOTE: Two recoveries did not include date and location of recapture.

Table 153. Seasonal movement of spot, *Leiostomus xanthurus*, tagged in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Season	Length Group (mm)	Direction Moved By Recaptured Tagged Fish: Caught In Area Of Release	Movement Within Estuary: Creek to Beach	Movement Within Estuary: Beach To Creek	Movement Out Of Estuary: North	Movement Out Of Estuary: South
Winter	101-150	-	-	-	-	-
	151-200	-	-	-	-	1
	Total	-	-	-	-	1
	Percent	-	-	-	-	100.0
Spring	101-150	-	1	-	1	-
	151-200	-	1	1	2	1
	Total	-	2	1	3	1
	Percent	-	28.6	14.3	42.8	14.3
Summer	101-150	-	-	-	-	-
	151-200	1	-	-	-	1
	Total	1	-	-	-	1
	Percent	50.0	-	-	-	50.0
Fall	101-150	-	-	-	-	-
	151-200	1	-	-	-	-
	Total	1	-	-	-	-
	Percent	100.0	-	-	-	-
Combined	Total	2	2	1	3	3
	Percent	18.2	18.2	9.0	27.3	27.3

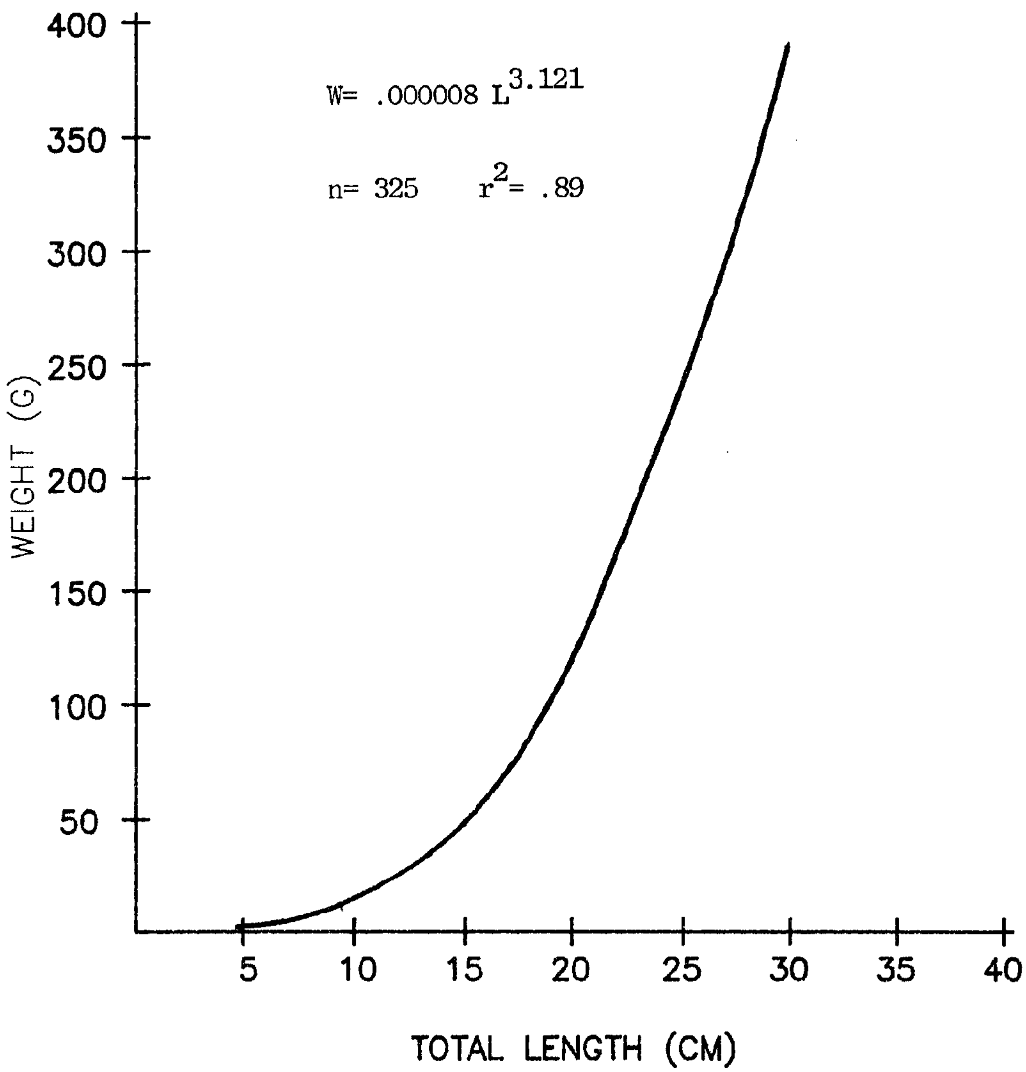

Figure 38. Length-weight relationship of spot, *Leiostomus xanthurus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Table 154. Comparison of total length-weight relationships for several populations of spot, *Leiostomus xanthurus*.

Study	Location	Length-Weight Equation	Weight of Fish (g)		
			100 mm	175 mm	250 mm
Dawson (1958)	South Carolina	$\log W = 2.958 \log L - 4.544$[1/]	14	74	212
Dawson (1965)	Mississippi and Louisiana	$\log W = 3.071 \log L - 5.036$	13	71	213
Present Study	Georgia	$\log W = 3.121 \log L - 5.096$	14	80	244

1/ Standard lengths converted to total lengths using the formula TL = 1.19 SL.

rings, Welsh and Breder (1924) and Barger and Johnson (1980) reported difficulty in age determination for spot collected in New Jersey and the Gulf of Mexico. Sundararaj (1960) and Barger and Johnson (1980) presented evidence verifying that otoliths can be used for valid age determinations of spot.

Pacheco (1962) described the scale annulus as a densely packed, narrow band of circuli associated with incomplete or broken circuli in the anterior portion of the scale area. These densely packed or interrupted circuli appear as branched, broken, fragmented or terminated circuli. Circuli before and after these dense rings are usually complete and uniform. Scale annuli were also characterized by light cutting over of new circuli in the lateral regions of the scale and formation of new radii.

Scale samples from 319 spot ranging from 42 to 283 mm were examined, and 246 (77%) were considered usable for age analyses. Otoliths from these 246 spot were also examined to validate the scale annuli counts. Scale annuli and otolith rings formed simultaneously.

Calculation of mean monthly growth of marginal increments indicated scale annuli are formed only once annually from late February through early April.

Length-square regression analyses on the relationship between fish length and scale radius yielded an r^2 value of 0.62 ($P < 0.0001$), suggesting that back-calculations based on fish length-scale radius would be reliable for estimating fish length at time of annulus formation. Empirical and mean back-calculated total lengths at age for spot are shown in Table 155. Table 156 shows the empirical and weighted mean back-calculated lengths for juvenile, male, female, and all spot combined. Table 27 shows length-age equations for male, female, and all spot combined, and Figure 39 illustrates the length-age relationships.

Rosa Lee's phenomena (Ricker, 1975) was observed in back-calculated ages for spot. It was observed for the first year's growth for three year classes of spot (Table 155). This may be a result of ageing fish

Table 155. Mean back-calculated total lengths for spot, *Leiostomus xanthurus*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back-Calculated Lengths of Successive Scale Rings		
				1	2	3
0	32	42 - 216	161			
1	109	125 - 237	191	147		
2	94	182 - 255	224	110	203	
3	11	210 - 283	242	98	181	219
	Weighted Means			128	201	219
	Growth Increments			128	73	18

NOTE: Lengths measured in millimeters.

Table 156. Number, empirical and back-calculated total lengths, and growth increments by sex and age for spot, *Leiostomus xanthurus*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Sex	Age 1	Age 2	Age 3
Juveniles			
Number	20		
Mean Length at Capture	164		
Back-Calculated Length	143		
Growth Increment	143		
Males			
Number	40	41	3
Mean Length at Capture	197	223	242
Back-Calculated Length	134	203	215
Growth Increment	134	69	12
Females			
Number	48	53	8
Mean Length at Capture	197	225	242
Back-Calculated Length	121	199	220
Growth Increment	121	78	21
Combined			
Number	109	84	11
Mean Length at Capture	191	224	242
Back-Calculated Length	128	201	219
Growth Increment	128	73	18

NOTE: Lengths measured in millimeters.

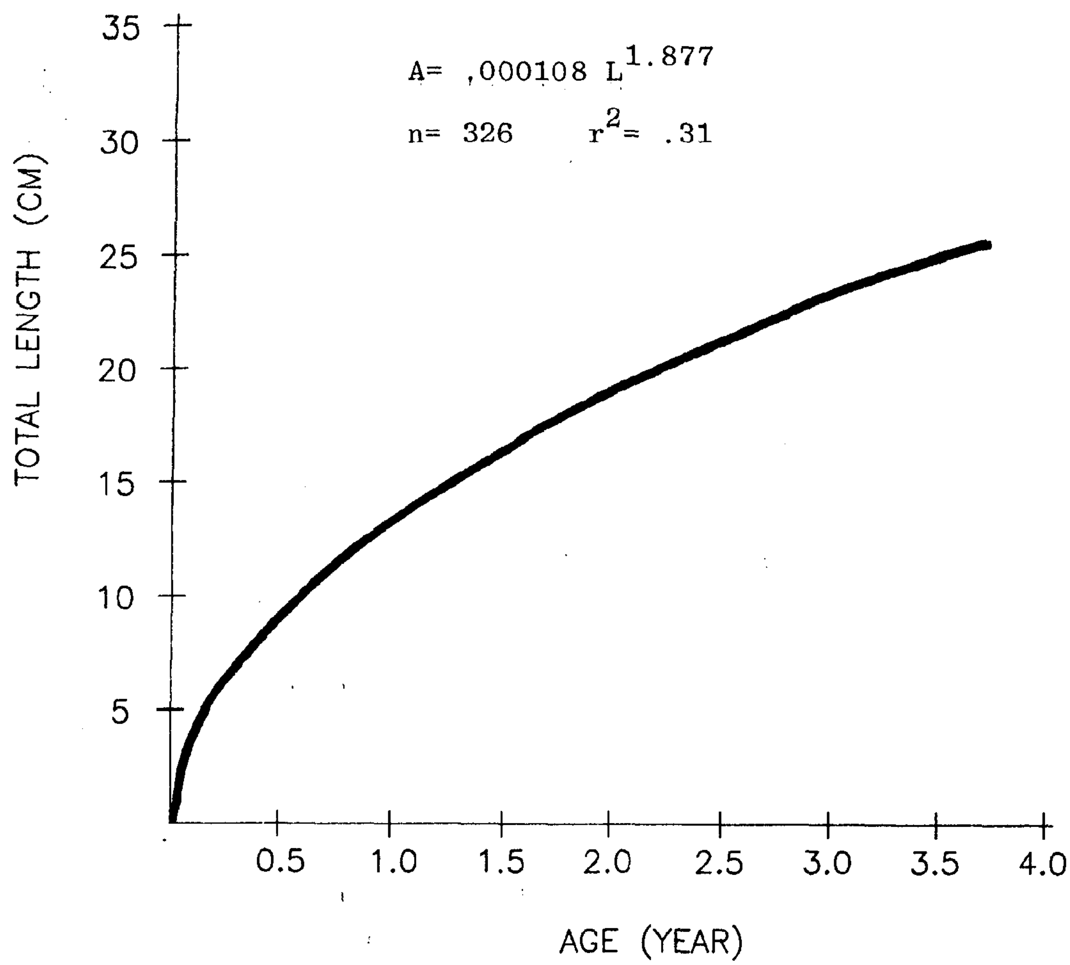

Figure 39. Length-age relationship of spot, *Leiostomus xanthurus*, collected in Glynn County, Georgia.

collected immediately after two severe winters. The 1977 and 1978 winters were designated by the Federal Government as "shrimp disasters" and may have produced conditions detrimental to growth and survival of spot. Of 246 spot aged, 159 (65%) were collected during 1979 and 1980, and 221 (90%) were collected from 1979 through 1981. The remaining 25 spot were collected during 1982. The first and second year's growth of most three year old spot occurred concurrently with these severe winters. The same was true for the first year's growth of two year old spot. Therefore, it is assumed that growth of spot was probably stunted during 1977 and 1978, and that the first year's growth for age I spot (147 mm) may be closer to the expected growth rate. Unfortunately, tag returns were insufficient to document growth rates.

Ricker (1975) discussed the introduction of an "artificial" Lee's phenomenon into back-calculations of size from annuli measurements. Ricker stated, ". . . if scale annuli are taken as directly proportional to body length in a population where they are actually proportional to length less a constant quantity, the calculated first-year growth is always too small and it becomes smaller, the greater the age of fish from which it is calculated." However, the correction factor (Y intercept) value of -5.203 derived for the body length-scale radius relationship was applied as the constant in back-calculation of spot lengths. The results were similar to the lengths shown in Table 155. Therefore, it is assumed that correct techniques were used for spot in back-calculation of successive scale annuli.

Barger and Williams (1980) derived a "compositive growth rate" based on six regression equations derived from various age and growth investigations for spot. Their derived hyperbolic function was:

$$Y = \frac{X}{A+BX}$$

where Y = mean total length in millimeters
X = age in months
A = 6.89×10^{-2}
B = 2.20×10^{-3}

Therefore, Barger and Williams' (1980) compositive growth for 12, 24, and 36 month old spot was 126, 197, and 243 mm, respectively. Their values were similar to back-calculated lengths for Georgia spot (Table 155).

Maturity and Spawning

During this study, the smallest specimens examined for which sex could be determined through gross examination of gonads were 129 mm for females and 132 mm for males. These specimens were both age I, or in their second year of life. The smallest specimens to exhibit developing gonads (stage III or higher) were 209 mm (age I) for females and 221 mm (age I) for males.

Music (1974) noted in an earlier study in Georgia that the smallest spot exhibiting advanced gonadal development (stages IV through VI) measured 175 mm TL (6.9 inches) for males and 210 mm (8.3 inches) for females. The ages were not reported for these fish, but from information collected from this study these fish would be approximately age II. Apparently, first spawning is generally after fish exceed 170 mm (6.7 inches) as similar sizes have been reported in other areas (Pearson, 1929; Townsend, 1956; and Dawson, 1958). Dawson (1958) also reported that the majority of spawning and near-spawning spot in South Carolina are considered to be late two and early three years old fish.

No spawning activity was observed for spot during this study, and no advanced stages of gonadal development were collected. Only resting (stage I) or early developing gonads (stages II and III) were collected (Table 157). All fish collected from salinities <16 $^{o}/oo$ were stage I or "resting stage." All stage II fish were collected at salinities of 16-30 $^{o}/oo$ while the four stage III females were collected from salinities above 26 $^{o}/oo$ in the sounds (Table 158). Furthermore, these stage III females were collected from the sounds in February when water temperature was less than 15^{o}C (Table 159).

Welsh and Breder (1924) reported spot spawning in late fall or early winter. Pearson (1929) reported similar fall and winter spawning in the Gulf of Mexico at passes leading to intracoastal waters from December until March, with peak activity in January and February. He also

Table 157. Number of spot, *Leiostomus xanthurus*, collected by month, sex and reproductive stage for the period January 1979 through June 1982.

	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
Month	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January			1	0										
February	6	12	2	1	4	0								
March	29	49												
April	31	5												
May	9	3												
June	22	16												
July	9	12												
August	23	1												
September	9	4												
October	10	10	11	5										
November														
December														

Table 158. Stages of gonadal development for spot, *Leiostomus xanthurus*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

		Surface Water Salinity (0/00)																	
	Reproductive	0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		Totals	
Month	Stage	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I	-	-	0	1	1	1	-	-	0	1	5	9	-	-	-	-	6	12
	II	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	2	1
	III	-	-	-	-	-	-	-	-	-	-	4	0	-	-	-	-	4	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I	-	-	-	-	7	5	1	7	21	37	-	-	-	-	-	-	29	49
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	-	-	2	0	4	0	1	1	15	4	1	0	8	0	-	-	31	5
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	I	-	-	-	-	0	1	3	0	3	2	3	0	-	-	-	-	9	3
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	I	-	-	-	-	-	-	-	-	9	7	13	8	0	1	-	-	22	16
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
July	I	-	-	-	-	1	0	-	-	4	6	3	5	1	1	-	-	9	12
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	I	-	-	-	-	-	-	-	-	5	1	-	-	18	0	-	-	23	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I	-	-	-	-	-	-	-	-	4	4	5	0	-	-	-	-	9	4
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I	-	-	-	-	-	-	2	4	2	3	6	3	-	-	-	-	10	10
	II	-	-	-	-	-	-	3	1	2	3	6	1	-	-	-	-	11	5
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combined Total	I	-	-	2	1	13	7	7	12	63	65	36	25	27	2	-	-	148	112
	II	-	-	-	-	-	-	4	1	2	3	8	2	-	-	-	-	14	6
	III	-	-	-	-	-	-	-	-	-	-	4	0	-	-	-	-	4	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 159. Stages of gonadal development for spot, *Leiostomus xanthurus*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)	Reproductive Stage	Surface Water Temperature (°C) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	Totals F	Totals M
6-10	I	-	-	0	1	-	-	-	-	2	0	-	-	-	-	2	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-15	I	-	-	1	1	0	3	7	3	4	0	1	0	-	-	13	7
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	-	-	1	0	0	7	5	5	1	0	-	-	7	12
16-20	II	-	-	-	-	1	0	-	-	3	1	-	-	-	-	4	1
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	-	-	15	29	18	13	5	2	25	21	-	-	63	65
21-25	II	-	-	-	-	-	-	-	-	-	-	2	3	-	-	2	3
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	2	0	2	2	2	7	10	3	20	13	-	-	36	25
	II	-	-	1	1	1	0	-	-	6	1	-	-	-	-	8	2
26-30	III	-	-	2	0	2	0	-	-	-	-	-	-	-	-	4	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-35	I	-	-	-	-	-	-	-	-	8	0	4	2	15	0	27	2
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	3	2	18	34	27	30	34	10	51	36	15	0	148	112
	II	-	-	1	1	2	0	-	-	9	2	2	3	-	-	14	6
TOTALS	III	-	-	2	0	2	0	-	-	-	-	-	-	-	-	4	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

reported first spawn at the end of the second year of life, followed by death of the spawners. Fall and winter spawning has been confirmed by workers in other areas (Hildebrand and Schroeder, 1928; Hildebrand and Cable, 1930; Dawson, 1958; Pacheco, 1962; Music, 1974, Mahood et al., 1974; Barger and Williams, 1980; Weinstein and Walters, 1981). Most investigators also agree that spawning takes place at sea with peak spawning from November through February. Pacheco (1962) reported that the fall migration of adults was coincidental with gonadal development.

From the occurrence of advanced maturities in Georgia, Music (1974) concluded that spawning begins in October and may continue as late as March, with the peak in November and December. He was unable to collect ripe females, but found two ripe males in November and two spent females in March in Wassaw Sound. Mahood et al. (1974) reported that juvenile spot, averaging 20 to 56 mm TL, were collected in seine samples in Georgia from February through May, with peak abundance in March in the northern section of the state.

Postlarval spot were identified in ichthyoplankton samples during January and February (Table 63). These specimens were collected in all three sectors in January, but in February they were concentrated primarily in the upper rivers and creeks. Young specimens were collected in 3-meter trawl samples primarily during winter and spring (Table 52). After abundance peaked in spring, their numbers dropped sharply in summer, and none were collected in the fall trawl samples. There was an increase in the abundance of young spot in trawl samples from the beaches upstream to the upper creeks, indicating a definite preference for the upper portion of the estuaries (Table 53).

Results from this and other investigations suggest that any spawning that takes place in Georgia's inside waters is in reduced amounts in the northern portion of the coastline.

The overall sex ratio of females to males during this study was 1.4:1 (Table 41), and was the same as reported in an earlier study in Georgia by Music (1974).

As shown in Table 40, spot exhibiting advanced reproductive stages were virtually absent in collections made in Georgia estuaries which prohibited the determination of fecundity for this species.

Food Preference and Feeding Habits

Food items identified in spot stomachs by 100 mm length groups are presented in Table 160. Of 321 spot stomachs examined to determine feeding habits, 282 (87.9%) contained food and 39 (12.1%) were empty. Spot are relatively small bottom feeders which consume a wide variety of organisms, most of which are benthic. Small spot <100 mm were found to contain mainly crustaceans and annelid worms. The most frequently occurring crustaceans were copepods, and the most frequently occurring annelids were *Heteromastus filiformis* and *Eteone* sp. In spot 101-200 mm crustaceans, primarily amphipods, and a variety of annelid worms and small mollusks were consumed. Spot >201 mm apparently ate every type of crustacean, mollusk and worm they could adequately ingest. The most frequently occurring items, however, were a variety of unidentified polychaetes, small mollusks, and crustaceans. Plant detritus and inorganic materials were frequently a significant portion of stomach contents, but were considered incidentally occurring materials resulting from benthic feeding behavior.

The 10 most commonly occurring food items found in spot stomachs by season and sector appear in Table 161. Annelid worms, mollusks and crustaceans were the most frequently ingested foods during winter. During spring, annelids were again the most important food but crustaceans also ranked high. Mollusks did not appear in the top 10 items. During summer, crustaceans became the dominant food source, but mollusks and annelids were also important. Plant detritus also occurred in many stomachs. The top occurring food items during fall were rhynchcoel worms and crustaceans, primarily amphipods and small mud crabs (*Panopeus* sp.). In general, any small invertebrate living in the benthic community is highly susceptible to predation by spot. Everything from young horseshoe crabs to fish were found, but the data indicate a definite preference for polychaetes and benthic crustaceans. Chao and Musick (1977) found that the dominant foods of spot in Virginia's York River were burrowing polychaetes. Stickney, Taylor and White (1975) found harpacticoid

Table 160. Stomach contents of spot, *Leiostomus xanthurus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group 1-100	101-200	201-300	301-400	Combined	Percent Occurrence	Average % Bolus
PISCES							
Pisces (unidentifiable)	3	6	8		17	6.0	<5
ARTHROPODA							
Crustacea (unidentifiable)	8	32	50	1	91	32.3	14
Acetes americanus			2		2	0.7	10
Alpheus heterochelis			2		2	0.7	50
Ampelisca abdita		1	3		4	1.4	<5
Amphipoda	6	26	34		66	23.4	10
Anthuridae		3	5	1	9	3.2	<5
Aoridae		2			2	0.7	10
Caprellidae		2	1		3	1.1	<5
Copepoda	10	5	9	1	25	8.9	6
Corophiidae	2		2		4	1.4	17
Corophium sp.	1				1	0.4	<5
Decapoda	5	5	22	1	33	11.7	25
Ericthonius brasiliensis			1		1	0.4	10
Eurypanopeus depressus			2		2	0.7	35
Gammarus sp.			2		2	0.7	35
Hexapanopeus angustifrons			1		1	0.4	10
Isopoda			1		1	0.4	<5
Melitidae		1	1		2	0.7	80
Monoculodes edwardsi	3				3	1.1	30
Monoculodes tesslatus	1	3			4	1.4	5
Mysidae			11		11	3.9	63
Neopanopeus sayi			1		1	0.4	<5
Ogyrides alphaerostris			1		1	0.4	<5
Ostracoda			2		2	0.7	5
Pagurus longicarpus			1		1	0.4	30

Table 160. (continued)

Food Item	Length Group 1-100	101-200	201-300	301-400	Combined	Percent Occurrence	Average % Bolus
ARTHROPODA (continued)							
Palaemonetes sp.			1		1	0.4	<5
Panopeus herbstii			15		15	5.3	10
Penaeus setiferus			2		2	0.7	5
Pinnixa chaetopterana			2		2	0.7	<5
Porcellana sayana			1		1	0.4	50
Portunus gibbesii			8		8	2.8	19
MEROSTOMATA							
Limulus polyphemus		1	4		5	1.8	<5
MOLLUSCA							
Mollusca (unidentifiable)		30	59	1	90	31.9	58
Chione cingenda			1		1	0.4	<5
Gastropoda			3		3	1.1	63
Littorina littorea			2		2	0.7	25
Mercenaria mercenaria			1		1	0.4	20
Modiolus demissus		1			1	0.4	<5
ANNELIDA and ASCHELMENTHES							
Aegothoa sp.			2		2	0.7	<5
Ampharete acutifrons	4	1			5	1.8	<5
Capitellidae	5	1	7		13	4.6	<5
Cirratulidae	1	1	14		16	5.7	26
Eteone sp.	9	3	12		24	8.5	<5
Exojone sp.		1			1	0.4	<5
Exojone dispar	5	1			6	2.1	<5
Glyceridae	1		3		4	1.4	<5
Glycinde solitaria	3		2		5	1.8	<5
Heteromastus filiformis	10	3	14		27	9.6	13
Kinorhyncha		1	1		2	0.7	<5
Lumbrineridae	3	1	3		7	2.5	<5

Table 161. The 10 most frequently occurring food items found in the stomachs of spots, *Leiostomus xanthurus*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Winter				Spring				Summer			
Sector	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus
Creeks	Bivalvia	37	56.9	80	Unidentified material	15	39.5	31	Plant Detritus	16	64.0	43
	Nematoda	17	26.2	69	Annelida	14	36.8	11	Bivalvia	11	44.0	71
	Unidentified material	16	24.6	44	Cirratulidae	13	34.2	29	Crustacea	7	28.0	3
	Orbiniidae	8	12.3	20	Nematoda	11	28.9	1	Amphipoda	6	24.0	15
	Annelida	7	10.8	51	*Spartina alterniflora*	10	26.3	10	Mollusca	5	20.0	60
	Nereidae	7	10.8	47	Animal tissue	9	23.7	27	Rhynchocoela	4	16.0	25
	Spionidae	7	10.8	6	Spionidae	9	23.7	11	Annelida	4	16.0	8
	Crustacea	5	7.7	18	Organic materials	8	21.1	75	Unidentified material	4	16.0	5
	Mediomastus sp.	5	7.7	10	Nereidae	7	18.4	17	*Portunus gibbesii*	3	12.0	40
	Capitellidae	5	7.7	4	*Streblospio benedicti*	7	18.4	12	*Penaeus setiferus*	2	8.0	5
Sounds	Plant detritus	24	77.4	41	Unidentified material	21	47.7	23	Plant detritus	11	91.7	23
	Crustacea	18	58.1	17	Annelida	20	45.5	51	Amphipoda	9	75.0	18
	Annelida	15	48.4	43	Crustacea	14	31.8	4	Rhynchocoela	7	58.3	3
	Amphipoda	12	38.7	11	*Spartina alterniflora*	12	27.3	8	Crustacea	5	41.7	20
	Unidentified material	11	35.5	43	Copepoda	12	27.3	1	Annelida	5	41.7	6
	Nematoda	7	22.6	3	Decapoda	10	22.7	24	Bivalvia	4	33.3	40
	Copepoda	6	19.4	13	Spionidae	10	22.7	<1	Decapoda	4	33.3	8
	Mediomastus sp.	3	9.7	5	Nematoda	10	22.7	<1	*Panopeus* sp.	3	25.0	37
	Bivalvia	3	9.7	13	Rhynchocoela	9	20.5	13	*Portunus gibbesii*	3	25.0	<1
	Spartina alterniflora	2	6.5	10	Plant detritus	8	18.2	26	Nematoda	3	25.0	<1
Beaches	NONE 1/	-	-	-	Unidentified material	7	58.3	41	Crustacea	20	74.1	26
					Mediomastus sp.	7	58.3	26	Bivalvia	15	55.6	23
					Spartina alterniflora	7	58.3	2	Sand	14	51.9	25
					Nereidae	5	41.7	40	Amphipoda	13	48.1	11
					Spionidae	5	41.7	24	Annelida	12	44.4	28
					Eteone sp.	5	41.7	8	Decapoda	8	29.6	18
					Crustacea	3	25.0	<1	Unidentified material	8	29.6	13
					Phyllodocidae	3	25.0	<1	Plant detritus	6	22.2	12
					Streblospio benedicti	3	25.0	<1	Rhynchocoela	6	22.2	5
					Gastropoda	1	8.3	90	Inorganic material	4	14.8	18
Offshore	Sand	1	100.0	60	NONE	-	-	-	NONE	-	-	-
	Bivalvia	1	100.0	10								
	Annelida	1	100.0	10								
	Crustacea	1	100.0	5								
	Amphipoda	1	100.0	5								
	Organic material	1	100.0	5								
Totals	Bivalvia	41	42.3	73	Sand	43	45.7	29	Plant detritus	33	51.6	30
	Unidentified material	27	27.8	44	Annelida	34	36.2	34	Crustacea	32	50.0	20
	Plant detritus	27	27.8	37	*Spartina alterniflora*	29	30.9	8	Bivalvia	30	46.8	43
	Nematoda	24	24.7	37	Spionidae	24	25.5	13	Amphipoda	28	43.8	14
	Crustacea	24	24.7	16	Crustacea	22	23.4	3	Annelida	21	32.8	19
	Annelida	23	23.7	6	Nematoda	21	22.3	1	Rhynchocoela	17	26.6	9
	Amphipoda	14	14.4	10	*Mediomastus* sp.	19	20.2	16	Sand	16	25.0	23
	Orbiniidae	8	8.2	20	*Eteone* sp.	18	19.1	3	Decapoda	14	21.9	15
	Mediomastus sp.	8	8.2	8	Plant material	16	17.0	48	Unidentified material	13	20.3	9
	Spionidae	8	8.2	6	Rhynchocoela	16	17.0	10	Pisces	7	10.9	3

1/ None denotes no specimens were collected with food in stomachs.

Table 161. (continued)

Sector	Fall				Combined Totals			
	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus
Creeks	Unidentified material	7	63.6	58	Bivalvia	52	37.4	77
	Plant detritus	7	63.6	16	Unidentified material	42	30.2	38
	Crustacea	4	36.4	<5	Plant detritus	32	23.0	33
	Bivalvia	3	27.3	70	Nematoda	29	20.9	5
	Rhynchocoela	3	27.3	<5	Annelida	26	18.7	22
	Mysidae	2	18.2	20	Crustacea	21	15.1	6
	Decapoda	2	18.2	10	Orbiniidae	19	13.7	10
	Amphipoda	2	18.2	<5	Spionidae	16	11.5	9
	Alpheus sp.	1	9.1	90	Nereidae	14	10.1	32
	Mollusca	1	9.1	90	Cirratulidae	14	10.1	29
Sounds	Plant Detritus	15	93.8	33	Plant detritus	58	56.3	33
	Rhynchocoela	12	75.0	2	Crustacea	46	44.7	13
	Amphipoda	11	68.8	7	Annelida	43	41.7	40
	Sand	10	62.5	6	Amphipoda	39	37.9	10
	Panopeus sp.	10	62.5	3	Unidentified material	37	35.9	29
	Crustacea	9	56.3	18	Rhynchocoela	28	27.2	6
	Unidentified material	4	25.0	33	Nematoda	20	19.4	1
	Mollusca	4	25.0	20	Copepoda	19	18.4	6
	Annelida	3	18.8	23	*Spartina alterniflora*	15	14.6	11
	Littorina littorea	2	12.5	25	*Panopeus* sp.	14	13.6	11
Beaches	NONE 1/	-	-	-	Crustacea	23	59.0	22
					Unidentified material	15	38.5	26
					Bivalvia	15	38.5	23
					Sand	14	35.9	25
					Amphipoda	13	33.3	11
					Annelida	12	30.8	28
					Decapoda	8	20.5	18
					Spartina alterniflora	7	17.9	2
					Plant detritus	6	15.4	12
					Rhynchocoela	6	15.4	5
Offshore	NONE	-	-	-	Sand	1	100.0	60
					Bivalvia	1	100.0	10
					Annelida	1	100.0	10
					Crustacea	1	100.0	5
					Amphipoda	1	100.0	5
					Organic materials	1	100.0	5
Totals	Plant detritus	22	71.0	28	Plant detritus	96	34.0	32
	Rhynchocoela	15	48.4	1	Unidentified material	94	33.0	33
	Crustacea	13	41.9	12	Crustacea	91	32.3	14
	Amphipoda	13	41.9	5	Annelida	82	29.1	32
	Unidentified material	11	35.5	48	Bivalvia	79	28.0	58
	Panopeus sp.	10	32.3	23	Amphipoda	66	23.4	10
	Sand	10	32.3	6	Nematoda	50	17.7	<5
	Mollusca	5	16.1	34	Rhynchocoela	48	17.0	7
	Annelida	4	12.9	23	*Spartina alterniflora*	36	12.8	8
	Bivalvia	3	9.7	70	Decapoda	33	11.7	25

1/ None denotes no specimens were collected with food in stomachs.

copepods to be the dominant food in spot <200 mm SL in Georgia. Summaries of food habits for spot are presented in Dawson (1958) and Chao and Musick (1977).

Annelid worms and mollusks were the dominant food in the creeks (Table 161). The major food items in the sounds were crustaceans and annelids, while on the beaches crustaceans and mollusks were encountered most often. Of those spot stomachs examined from offshore waters, there was near even distribution of mollusks, annelid worms and crustaceans. However, too few specimens were collected from offshore waters to draw accurate conclusions for this area.

Seasonal feeding activity was apparently greatest during spring as 95.9% of the stomachs examined contained food (Table 162). Summer and winter feeding activity were only slightly lower with 88%, and feeding activity was lowest during fall when 75.9% contained food.

A definite trend in increased feeding activity was observed between sectors as the percentage of stomachs containing food increased from the creeks (81.3%) to the sounds (93.6%) to the beaches and offshore waters with 100.0% (Table 162).

Water temperature apparently did not significantly alter the feeding habits of spot as over 75% of the stomachs examined contained food in all temperature ranges (Table 50).

Spot fed actively throughout the lunar month except during the three days preceding and during new moon when only 38.5% of the stomachs examined contained food (Table 51). During all other moon phases over 66.7% contained food. Highest feeding activity apparently occurred during the week preceding full moon and the three days before last quarter as all stomachs examined contained food.

SOUTHERN KINGFISH

Southern kingfish (*Menticirrhus americanus*) may be found in most areas along the west Atlantic from Cape Cod to Buenos Aires, Argentina (Fischer, 1978). They generally prefer sand and firm bottom areas in estauries and nearby ocean waters. Juveniles may be found in abundance

Table 162. Number and percent of spot, *Leiostomus xanthurus*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	65	83.3	13	16.7	78	100.0	31	100.0	0	0.0	31	100.0	-	-	-	-	-	-
Spring	38	100.0	0	0.0	38	100.0	44	91.7	4	8.3	48	100.0	12	100.0	0	0.0	12	100.0
Summer	25	78.1	7	21.9	32	100.0	12	92.3	1	7.7	13	100.0	27	100.0	0	0.0	27	100.0
Fall	11	47.8	12	52.2	23	100.0	16	88.9	2	11.1	18	100.0	-	-	-	-	-	-
Total	139	81.3	32	18.7	171	100.0	103	93.6	7	6.4	110	100.0	39	100.0	0	0.0	39	100.0

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	1	100.0	0	0.0	1	100.0	97	88.2	13	11.8	110	100.0
Spring	-	-	-	-	-	-	94	95.9	4	4.1	98	100.0
Summer	-	-	-	-	-	-	64	88.9	8	11.1	72	100.0
Fall	-	-	-	-	-	-	27	65.9	14	34.1	41	100.0
Total	1	100.0	0	0.0	1	100.0	282	87.9	39	12.1	321	100.0

year around at all depths in the lower portion of the estuaries, while the adults move to offshore waters during the colder months.

Movement and Migration

From March 12, 1979 through June 28, 1982, 540 southern kingfish were tagged and released. Length frequencies of tagged kingfish are presented in 50 mm length groups in Table 163. Lengths (TL) of kingfish tagged with Howitt tags ranged from 146 to 400 mm and those tagged with Floy tags ranged from 116 to 352 mm. Length frequencies of kingfish tagged with each tag type appear in Table 164. Table 165 lists length frequencies of tagged southern kingfish in 20 mm groups by gear type used for capture.

Southern kingfish recaptures were returned from August 17, 1979 through September 8, 1982. Of 540 kingfish tagged, 26 (4.8%) were recaptured and tags returned. Recovery rates, when separated into 50 mm fish length groups, ranged as high as 9.2%. The number of fish released and recaptured, time at large, and distance traveled are presented in Table 163. Time at large ranged from 5 to 682 days with an average of 230 days. Distance traveled ranged as far as 537 km, averaging 44.1 km.

The overall recovery rate with Howitt tags was 7.5% and with Floy tags was only 0.9% (Table 164). Recovery rates, when separated into 50 mm length groups, ranged as high as 10.9% with Howitt tags and 2.6% with Floy tags.

Commercial fishermen were the major source of southern kingfish recoveries, accounting for 15 (57.7%) of 26 returns. The remaining 11 recoveries were caught by recreational fishermen (Table 11). Of 11 recreational recaptures, 9 (82%) included sufficient information to determine lengths of creel size fish. Lengths (TL) of recreational recaptures ranged from 213 to 360 mm with an average size of 299 mm (Table 12). Length frequencies of recaptures indicated that most creel size fish ranged between 250 and 350 mm with the highest percentage (44.5%) between 301 and 350 mm (Table 13).

The beaches and offshore areas produced 82% of all recoveries with 36.4 and 45.5%, respectively (Table 14). The creeks produced

Table 163. Number tagged, number and percent recaptured, days at large and distance traveled for southern kingfish, *Menticirrhus americanus*, in 50 mm length groups.

Length Group	Number Tagged	Number Recaptured	Percent Returned	Days At Large		Distance Traveled (km) 1/	
				Avg.	Max.	Avg.	Max.
101 - 150	39	0	0.0				
151 - 200	131	2	1.5	128	251	14.8	19
201 - 250	122	8	6.6	192	340	15.2	41
251 - 300	164	9	5.5	214	505	20.4	72
301 - 350	76	7	9.2	324	682	120.4	537
351 - 400	8	0	0.0				
Total	540	26	4.8	230	682	44.1	537

1/ Distance measured in kilometers from point of release to point of recapture.

Table 164. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for southern kingfish, *Menticirrhus americanus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag Number Tagged	Howitt Tag Number Returned	Howitt Tag Percent Recaptured	Floy Tag Number Tagged	Floy Tag Number Returned	Floy Tag Percent Recaptured	Combined Number Tagged	Combined Number Returned	Combined Percent Recaptured
125	2			37	1		39		
175	40	1	2.5	91	1	1.1	131	2	1.5
225	83	6	7.2	39	1	2.6	122	7	5.7
275	111	9	8.1	53			164	9	5.5
325	64	7	10.9	12			76	7	9.2
375	7			1			8		
Total	307	23	7.5	233	2	0.9	540	25	4.6

Table 165. Number of southern kingfish, *Menticirrhus americanus*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Gill Net (in)[1/] 2-7/8	Gill Net (in)[1/] 3-1/2	Trammel Net	Trawl	Hook/Line	Totals
110	-	-	-	3	-	3
130	-	-	-	14	-	14
150	-	-	-	36	-	36
170	-	-	-	51	-	51
190	-	-	-	63	3	66
210	1	-	1	60	6	68
230	-	-	-	28	4	32
250	-	-	-	35	9	44
270	-	-	-	44	24	68
290	1	-	-	56	17	74
310	3	1	-	33	6	43
330	5	-	1	15	2	23
350	1	-	-	12	1	14
370	-	-	-	-	-	-
390	2	-	-	2	-	4
Totals	13	1	2	452	72	540

[1/] Gill net sizes are stretch mesh measurements.

only one return (4.5%) while the sounds accounted for three (13.6%).

Spring produced 54.6% of recoveries while winter and fall produced the fewest with 13.6 and 4.5%, respectively (Table 15). Summer accounted for the remaining six (27.3%) returns.

Georgia residents fishing in state waters accounted for 10 (91%) of the 11 recreational recoveries. Of these Georgia fishermen, seven (70%) traveled 40 km or less to reach the location of recapture, and all fishermen traveled less than 120 km (Table 16). Bait and gear types used by recreational fishermen to catch southern kingfish were available for only nine recaptures. Three specimens were recaptured with seines and one was caught with a gill net in Florida. Gear and bait information were not obtained for two recreational recaptures. Five recreational recaptures were caught with dead shrimp (Table 17).

Only 13% of the kingfish recoveries were recaptured in the immediate area of release. Of 23 kingfish for which recapture location was known, 17 (74%) were recaptured within 25 km of the tagging site (Table 166). Three recoveries (13%) had traveled 26 to 50 km, and one recovery was taken from each of the following distance intervals: 51 to 100, 101 to 200, and over 500 km. The specimen that moved over 500 km was at large 682 days and recaptured with a haul seine in March, south of Surf City, North Carolina. This 356 mm specimen had traveled a distance of 537 km. Winter recoveries produced the greatest movement, averaging 304.8 km (Table 21).

Recoveries were insufficient to ascertain movement within the estuary, but movements out of the estuary both north and south were similar during all seasons (Table 167).

Length-Weight Relationship

The length-weight relationship of 195 southern kingfish, ranging from 90 to 388 mm and 7 to 734 g, was $\log W = 3.160 \log L - 5.360$. The correlation coefficient value for length-weight was 0.9900 ($P < 0.0001$). Least-squares regression analyses on the length-weight relationships for male, female, and all southern kingfish combined are shown in Table 24. Figure 40 illustrates length-weight relationships for southern

Table 166. Days at large and distance traveled for southern kingfish, *Menticirrhus americanus*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Days At Large	Distance Traveled (km)										Total	Percent
	0	0.1-1	1-5	6-25	26-50	51-100	101-200	201-300	301-500	Over 500		
1 - 50	3	-	-	-	-	-	-	-	-	-	3	13.0
51 - 100	-	-	-	3	1	-	-	-	-	-	4	17.4
101 - 150	-	-	2	-	-	-	1	-	-	-	3	13.0
151 - 200	-	-	2	-	-	-	-	-	-	-	2	8.7
201 - 300	-	-	-	4	1	-	-	-	-	-	5	21.8
301 - 500	-	-	-	3	1	-	-	-	-	-	4	17.4
501 - 750	-	-	-	-	-	1	-	-	-	1	2	8.7
Total	3	-	4	10	3	1	1	-	-	1	23	100.0
Percent	13.0	-	17.5	43.6	13.0	4.3	4.3	-	-	4.3	100.0	

Table 167. Seasonal movement of southern kingfish, *Menticirrhus americanus*, tagged in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

		Direction Moved By Recaptured Tagged Fish				
		Caught In Area	Movement Within Estuary		Movement Out Of Estuary	
Season	Length Group (mm)	Of Release	Creek to Beach	Beach To Creek	North	South
Winter	151-200	-	-	-	-	-
	201-250	-	-	-	-	-
	251-300	1	-	1	-	-
	301-350	-	-	-	1	-
	Total	1	-	1	1	-
	Percent	33.3	-	33.3	33.3	-
Spring	151-200	-	-	-	-	-
	201-250	-	-	-	1	2
	251-300	-	-	-	3	2
	301-350	-	1	-	1	-
	Total	-	1	-	5	4
	Percent	-	10.0	-	50.0	40.0
Summer	151-200	-	-	-	1	1
	201-250	1	-	-	-	3
	251-300	-	-	-	-	-
	301-350	1	-	-	2	6
	Total	1	-	-	2	6
	Percent	11.1	-	-	22.2	66.7
Fall	151-200	-	-	-	-	-
	201-250	-	-	-	-	-
	251-300	1	-	-	-	-
	301-350	-	-	-	-	-
	Total	1	-	-	-	-
	Percent	100.0	-	-	-	-
Combined	Total	3	1	1	8	10
	Percent	13.1	4.3	4.3	34.8	43.5

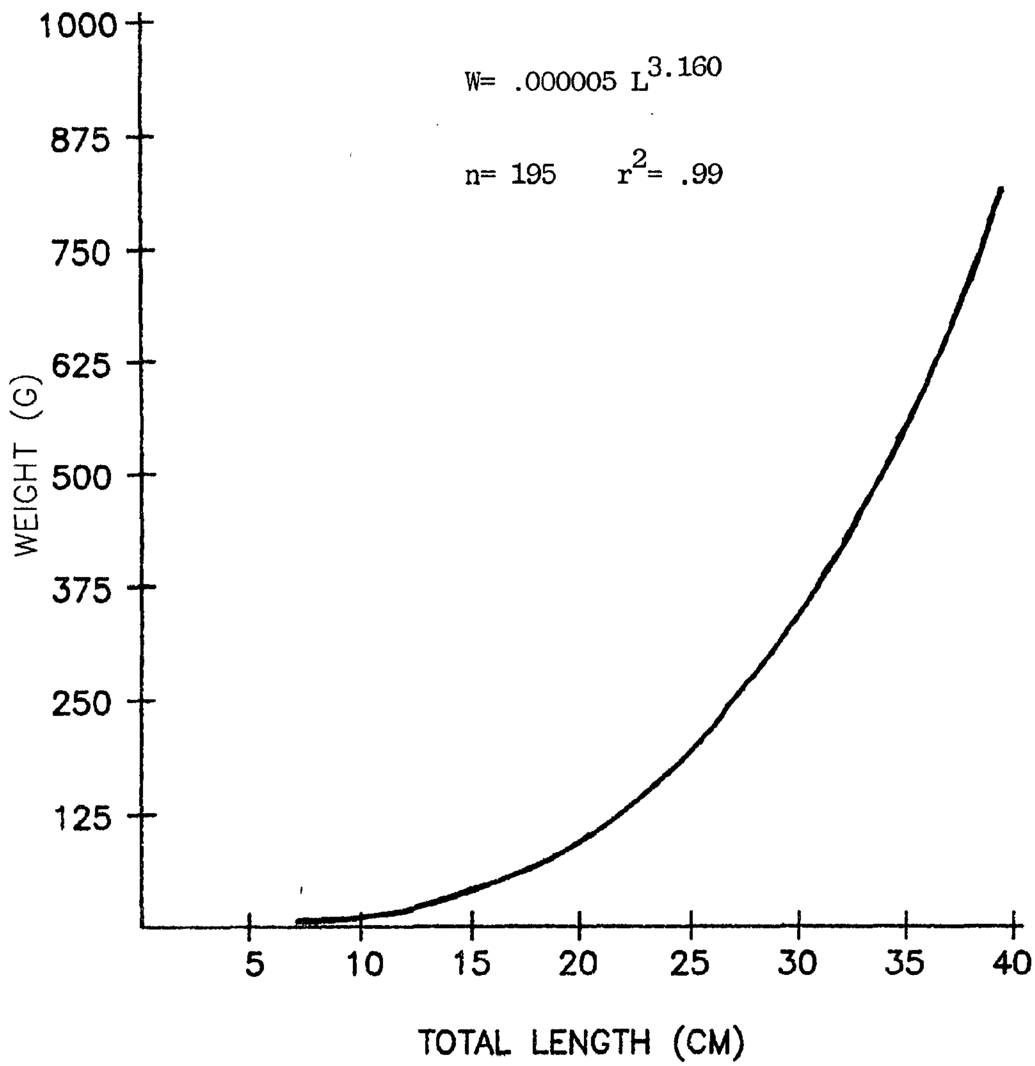

Figure 40. Length-weight relation of southern kingfish, *Menticirrhus americanus*, collected in Glynn County, Georgia from January 1979 through June 1982.

kingfish. The greatest lengths recorded for male and female Georgia kingfish were 319 and 388 mm, respectively. The heaviest male was 353 g and the heaviest female was 734 g.

Age and Growth

Available information on age and growth of southern kingfish has been based primarily on length-frequency analyses (Welsh and Breder, 1924; Hildebrand and Cable, 1934; Bearden, 1963). Welsh and Breder (1924) also examined scale samples from New Jersey kingfish and found that fish lengths derived from the scale annuli method confirmed their findings based on length-frequency analyses.

Scale samples from 215 southern kingfish ranging from 90 to 388 mm were examined, and 187 (87%) were considered legible for age analyses. Otolith sections from these 187 specimens were also examined and year mark formation on otoliths was found to be simultaneous with that of scales. The following scale characteristics were considered to be true annuli: heavy cutting over of circuli in the lateral regions of the scale, formation of new radii, and a narrow band of broken and fragmented circuli in the anterior region of the scale.

The calculation of mean monthly growth of marginal increments indicated that scale annuli were formed only once annually. Single annulus formation was detectable on scales during March and April, with all scales bearing recent annuli by mid-May.

Least-squares regression analyses on the relationship between fish length and scale radius yielded an r^2 value of 0.86 ($P < 0.0001$). Such results suggest the relationship to be sufficiently linear to warrant direct proportion calculations to determine fish length at time of annulus formation. The empirical and mean back-calculated lengths at age for southern kingfish are shown in Table 168. Weighted back-calculated lengths for juvenile, male, female, and all southern kingfish combined are contained in Table 169. Table 27 shows the length-age equations for male, female, and combined southern kingfish, and Figure 41 illustrates the length-age relationship of all kingfish combined.

Table 168. Mean back-calculated total lengths for southern kingfish, *Menticirrhus americanus*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

				Mean Back-Calculated Lengths of Successive Scale Rings			
Age	Number	Length Range at Capture	Mean Length at Capture	1	2	3	4
0	44	90 - 246	150				
1	93	105 - 338	202	145			
2	37	230 - 366	208	163	279		
3	9	293 - 387	330	173	270	316	
4	4	343 - 388	370	159	269	328	361
	Weighted Means			152	277	320	361
	Growth Increment			152	125	43	41

NOTE: Lengths measured in millimeters.

Table 169. Number, empirical and back-calculated total lengths, and growth increments by sex and age for southern kingfish, *Menticirrhus americanus*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Sex	Age 1	2	3	4
Juveniles				
Number	29	1		
Mean Length at Capture	146	230		
Back-Calculated Length	131	219		
Growth Increment	131	88		
Males				
Number	8	2	2	
Mean Length at Capture	179	297	302	
Back-Calculated Length	149	234	275	
Growth Increment	149	85	41	
Females				
Number	56	34	7	4
Mean Length at Capture	234	311	339	370
Back-Calculated Length	158	282	328	361
Growth Increment	158	124	46	33
Combined				
Number	93	37	9	4
Mean Length at Capture	202	308	330	370
Back-Calculated Length	152	277	320	361
Growth Increment	152	125	43	41

NOTE: Lengths measured in millimeters.

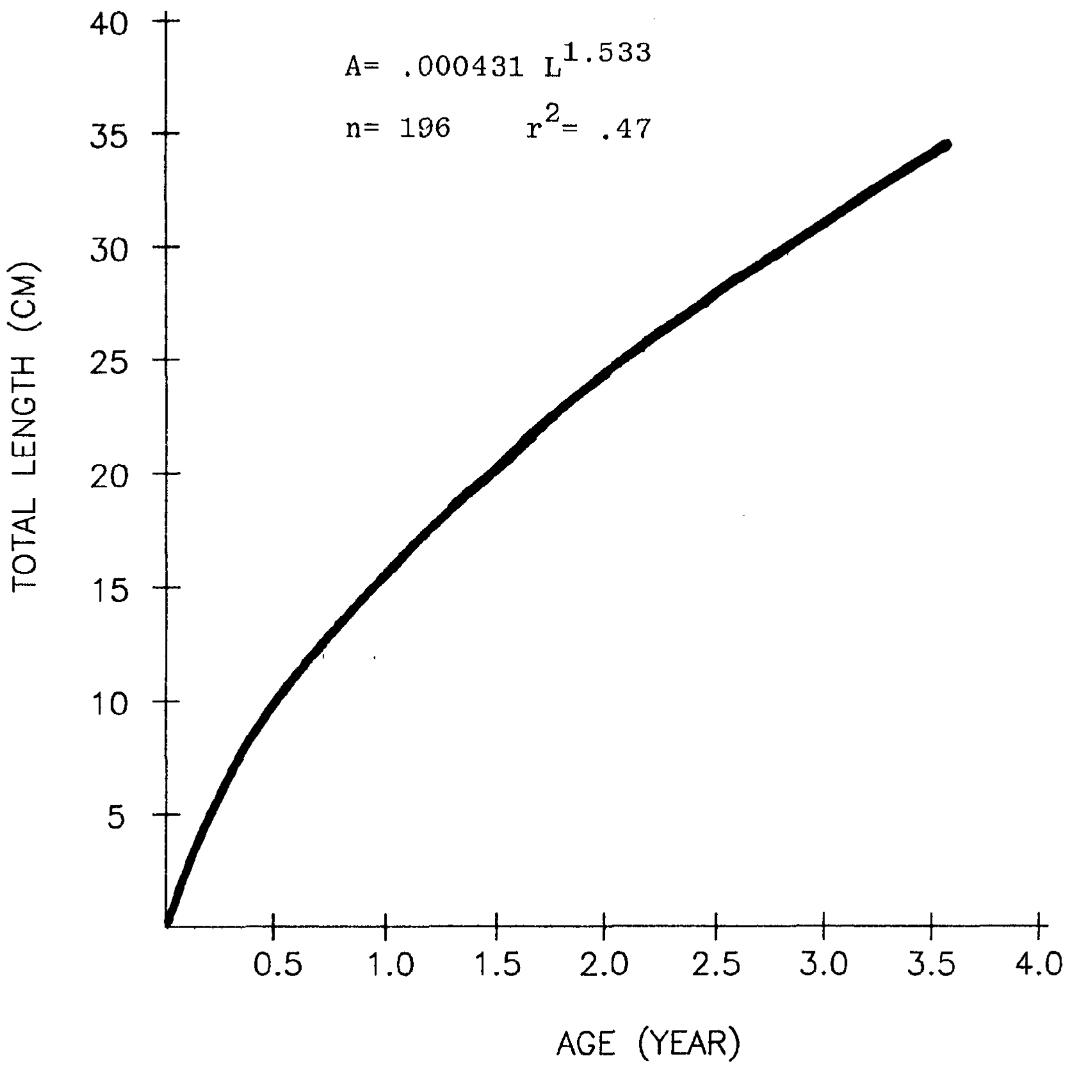

Figure 41. Length-age relationship of southern kingfish, *Menticirrhus americanus*, collected in Glynn County, Georgia.

Maturity and Spawning

The smallest specimens for which sex could be determined through gross examination were 147 mm for females and 142 mm for males. These specimens were age I, or in their second year of life. The smallest female exhibiting developing ovaries (stage III or greater) was 287 mm (age I). Stage II was the highest level of gonadal development observed in males, occurring in one specimen 293 mm (age III).

Bearden (1964) reported that sexual maturity in South Carolina males was reached at 195 mm SL, probably two years old or slightly less, and in females at 230-250 mm SL, or approximately two to three years of age.

Southern kingfish are present in Georgia waters the year around, but adults appear in greatest numbers in early spring and are collected throughout the warmer months. The spawning period in Georgia was previously reported as March through August by Mahood et al. (1974). From the maturity data collected during this study it appears that spawning development probably begins in March and continues as late as September, with peak spawning activity during April and May (Table 170). Although very few adults exhibiting advanced stages of gonadal development were collected, three stage V females were collected inside St. Simons Sound and one stage VI male was collected from the beach. Since no ripe females or males were collected from inside waters, it is probable that the vast majority of adults spawn in ocean waters although some spawning probably also takes place along the beaches and in the lower sounds. Music (personal observation) collected running ripe female southern kingfish approximately six nautical miles offshore from Jekyll Island at night during June in approximately 10 meters of water during experimental trawling for brown shrimp in 1974. Mahood et al. (1974) reported collection of young southern kingfish in the creeks and rivers during seining operations only during July in the southern portion of the state. They also reported that juveniles were more dependent on large rivers and sounds as nursery areas than most other species although they did use the upper creeks and marshes to a limited extent.

Table 171 presents the maturity stages by month and salinity gradient.

Table 170. Number of southern kingfish, *Menticirrhus americanus*, collected by month, sex and reproductive stage for the period January 1979 through June 1982.

	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
Month	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	5	1												
February	4	1												
March	24	4	16	1	2	0								
April	1	0	2	3	5	0			2	0	0	1		
May	8	1	3	0					1	0				
June	1	0	4	0										
July	18	1	5	0	2	0								
August	9	0	1	0	2	0								
September	4	0	1	0	1	0								
October	3	0												
November	5	0												
December	9	1												

Table 171. Stages of gonadal development for southern kingfish, *Menticirrhus americanus*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

		Surface Water Salinity (0/00)																	
	Reproductive	0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		TOTALS	
Month	Stage	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	I	-	-	-	-	-	-	-	-	2	0	3	1	-	-	-	-	5	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I	-	-	-	-	-	-	-	-	3	1	1	0	-	-	-	-	4	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I	-	-	-	-	-	-	1	0	-	-	3	1	20	3	-	-	24	4
	II	-	-	-	-	-	-	2	0	1	1	6	0	7	0	-	-	16	1
	III	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	IV-VU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	II	-	-	-	-	-	-	1	0	0	3	-	-	1	0	-	-	2	3
	III	-	-	1	0	1	0	-	-	3	0	-	-	-	-	-	-	5	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	VI	-	-	-	-	-	-	-	-	0	1	-	-	-	-	-	-	0	1
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	I	-	-	-	-	-	-	-	-	6	1	2	0	-	-	-	-	8	1
	II	-	-	-	-	-	-	-	-	1	0	1	0	1	0	-	-	3	0
	III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	I	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	II	-	-	-	-	-	-	-	-	-	-	3	0	1	0	-	-	4	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 171. (continued)

Month	Reproductive Stage	Surface Water Salinity (0/00) 0-5 F	M	6-10 F	M	11-15 F	M	16-20 F	M	21-25 F	M	26-30 F	M	31-35 F	M	36-40 F	M	TOTALS F	M
July	I	-	-	-	-	-	-	-	-	1	0	5	0	12	1	-	-	18	[illegible]
	II	-	-	-	-	-	-	-	-	-	-	1	0	4	0	-	-	5	[illegible]
	III	-	-	-	-	-	-	1	0	-	-	1	0	-	-	-	-	2	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	I	-	-	-	-	-	-	-	-	-	-	-	-	9	0	-	-	9	0
	II	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	III	-	-	-	-	-	-	-	-	1	0	-	-	1	0	-	-	2	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I	-	-	-	-	-	-	2	0	1	0	1	0	-	-	-	-	4	0
	II	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	III	-	-	-	-	-	-	1	0	-	-	-	-	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I	-	-	-	-	-	-	-	-	1	0	1	0	1	0	-	-	3	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I	-	-	-	-	-	-	2	0	-	-	3	0	-	-	-	-	5	0
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I	-	-	-	-	-	-	-	-	4	1	2	0	3	0	-	-	9	1
	II-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combined Total	I	-	-	-	-	-	-	5	0	19	3	21	2	46	4	-	-	91	9
	II	-	-	-	-	-	-	3	0	2	4	12	0	15	0	-	-	32	4
	III	-	-	1	0	1	0	2	0	4	0	3	0	1	0	-	-	12	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	1	0	2	0	-	-	-	-	3	0
	VI	-	-	-	-	-	-	-	-	0	1	-	-	-	-	-	-	0	1
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

All advanced maturity stages were collected at salinities above 21 ‰ during April and May. Beginning development (stage III) occurred at water temperature above 16°C while more advanced stages were collected after water temperature exceeded 21°C (Table 172). No correlation could be made between spawning development and lunar phase as too few specimens were collected (Table 40).

No larval or postlarval southern kingfish were identified in ichthyoplankton samples (Table 63). However, young specimens were collected in trawl samples throughout the year. The lowest occurrence of young kingfish occurred during winter, but their numbers increased through spring and peaked in summer before again dropping sharply in fall (Table 52). Young specimens were collected throughout the estuaries but their occurrence increased steadily from the creeks toward the beaches (Table 53).

Hildebrand and Cable (1934) reasoned from the abundance of larvae at Beaufort, North Carolina that the principal spawning season for that area seemed to extend from the latter part of June through July and August. They further concluded that spawning probably occurs chiefly along outside shores although some spawning may take place within inside waters. Bearden (1963) reported that mature specimens with developing roe were found in South Carolina in April and June, and one nearly ripe female was found in July. Therefore, he presumed that spawning takes place largely or entirely offshore since no fully ripe females were collected. He concluded that the spawning season in South Carolina extends about the same period of time as was reported by Hildebrand and Cable (1934). Our results seem to follow that of Bearden in that spawning takes place largely or entirely at sea.

The sex ratio of female to male southern kingfish during this study was 10.6:1 (Table 41).

As shown in Table 40, southern kingfish exhibiting advanced reproductive stages of gonadal development were virtually absent in collections made in Georgia estuaries. This absence prohibited detailed analyses of fecundity. However, fecundity was estimated to be approximately 198,000 eggs for one age II, 334 mm specimen. The total weight of this fish was

Table 172. Stages of gonadal development for southern kingfish, *Menticirrhus americanus*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)	Reproductive Stage	Surface Water Temperature (°C) 0-5 F	0-5 M	6-10 F	6-10 M	11-15 F	11-15 M	16-20 F	16-20 M	21-25 F	21-25 M	26-30 F	26-30 M	31-35 F	31-35 M	Totals F	Totals M
0-5	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-10	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-15	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-20	I	-	-	-	-	-	-	3	0	-	-	2	0	-	-	5	0
	II	-	-	1	0	-	-	2	0	-	-	-	-	-	-	3	0
	III	-	-	-	-	-	-	-	-	-	-	2	0	-	-	2	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-25	I	-	-	-	-	9	2	-	-	8	1	2	0	-	-	19	3
	II	-	-	-	-	-	-	1	4	1	0	-	-	-	-	2	4
	III	-	-	-	-	-	-	3	0	-	-	1	0	-	-	4	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	1	0	-	-	-	-	1	0
	VI-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-30	I	-	-	1	0	4	1	6	1	4	0	6	0	-	-	21	2
	II	-	-	-	-	-	-	4	0	3	0	5	0	-	-	12	0
	III	-	-	-	-	-	-	-	-	2	-	-	-	1	0	3	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	2	0	-	-	-	-	2	0
	VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-35	I	-	-	-	-	23	3	-	-	-	-	16	1	7	0	46	4
	II	-	-	-	-	7	0	-	-	2	0	4	0	2	0	15	0
	III	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	IV-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	I	-	-	1	0	36	6	9	1	12	1	26	1	7	0	91	9
	II	-	-	1	0	7	0	7	4	6	0	9	0	2	0	32	4
	III	-	-	-	-	-	-	-	-	3	0	4	0	1	0	8	0
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	3	0	-	-	-	-	3	0
	VI-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

439 g, with the gonads making up approximately 17% (75.9 g) of its total weight.

Food Preference and Feeding Habits

Although southern kingfish or "whiting" are relatively small fish with rather small mouths, they are very aggressive and voracious bottom feeders which eat a variety of organisms. Of 226 southern kingfish stomachs examined to determine food preferences and feeding habits, 188 (83.2%) contained food and 38 (16.8%) were empty. Food items identified in stomachs by fish length, in 100 mm groupings, are presented in Table 173.

In young kingfish <100 mm small mollusks were the most frequently occurring item although crustaceans and annelid worms were also ingested. Crustaceans in stomach contents included amphipods and fiddler crabs, but only *Uca minax* was identified to species. In specimens 101-300 mm the primary foods were crustaceans, annelid worms and mollusks. This size group also began to utilize fish such as snake eels (*Ophichthus ophis*) and blackcheeked tonguefish (*Symphurus plagiusa*). In specimens >301 mm fish became as important as crustaceans. A variety of fish species were observed in the stomachs of larger specimens but star drum (*Stellifer lanceolatus*) was the only species found in replicate. The most frequently occurring crustacean was the lady crab (*Ovalipes ocellatus*) although penaeid shrimp and grass shrimp were also important. No mollusks were observed in the stomachs of larger specimens, but annelid worms remained a major food component.

The 10 most frequently occurring food items are presented by season and sector in Table 174. Crustaceans were the primary food source in the creeks and rivers, but fish were also ingested. Major crustaceans included blue crabs (*Callinectes sapidus*) and mantis shrimp (*Squilla* sp.). Major fish species included snake eels and blackcheek tonguefish. In the sounds kingfish fed primarily on fish, crustaceans, and annelid worms. Top food items identified were grass shrimp (*Palaemonetes* sp.), mantis shrimp, and the small portunid crab (*Portunus gibbessii*). No specific fish species ranked in the top 10 food items identifed from the sounds. The most commonly occurring food item on the beaches was the commercial white

Table 173. Stomach contents of southern kingfish, *Menticirrhus americanus*, collected in Glynn County, Georgia from January 1979 through June 1982.

Food Item	Length Group (mm) 1-100	101-200	201-300	301-400	401-500	501-600	Combined	Percent Occurrence	Average % Bolus
PISCES									
Pisces (unidentifiable)		6	17	15			38	20.2	45
Anchoa mitchilli				1			1	0.5	70
Anguilla rostrata				1			1	0.1	90
Brevoortia tyrannus				1			1	0.5	90
Centropristis philadelphica				1			1	0.5	<5
Gymnothorax sp.				1			1	0.1	<5
Ophichthus ophis		1	1	1			3	1.6	90
Paralichthys dentatus				1			1	0.5	90
Stellifer lanceolatus				2			2	1.1	70
Symphurus plagiusa		2		1			3	1.6	80
Urophycis regia				1			1	0.5	90
ARTHROPODA									
Crustacea (unidentifiable)	1	13	12	3			29	15.4	32
Acetes americanus		6					6	3.2	43
Alpheus heterochelis		1	2				3	1.6	25
Amphipoda	1	5	1				7	3.7	26
Anthuridae		1					1	0.1	30
Arenaeus cribrarius		1					1	0.1	90

Table 173. (continued)

Food Item	Length Group (mm)						Combined	Percent Occurrence	Average % Bolus
	1-100	101-200	201-300	301-400	401-500	501-600			
ARTHROPODA (continued)									
Callianassa atlantica		1	4				5	2.7	65
Callinectes sapidus				1			1	0.1	90
Cyathura polita			1	1			2	1.1	90
Decapoda		12	11	1			24	12.8	48
Diastylidae		1					1	0.1	<5
Emerita talpoida		2					2	1.1	65
Gammarus sp.		1					1	0.1	<5
Haustoriidae				1			1	0.1	10
Hexapanopeus angustifrons				1			1	0.1	40
Mysidae		2	1	1	1		5	2.7	35
Ogyrides alphaerostris		2					2	1.1	60
Ovalipes ocellatus				5			5	2.7	48
Oxyurostylis smithi		1					1	0.1	<5
Pagurus longicarpus		1	2				3	1.6	60
Palaemontes sp.		5		2	1		8	4.3	84
Panopeus herbstii		2	7				9	4.8	60
Penaeidae		2	3	1			6	3.2	67
Penaeus setiferus		1	18	2			21	11.2	78
Pinnixa chaetopterana		1					1	0.1	80
Procellana sayana			1				1	0.1	50
Portunus gibbesii		5	5				10	5.3	64
Sesarma reticulatum		1					1	0.1	20
Squilla empusa		2	6	1			9	4.8	70
Trachypeneus constrictus		3	1		1		5	2.7	73
Uca minax	1						1	0.1	<5

Table 173. (continued)

Food Item	Length Group (mm) 1-100	101-200	201-300	301-400	401-500	501-600	Combined	Percent Occurrence	Average % Bolus
MOLLUSCA									
Mollusca (unidentifiable)	5	3	1				9	4.8	44
Gastropoda		1	1				2	1.1	90
Nudibranchia		2					2	1.1	15
Tellinidae		1					1	0.1	5
CEPHALOPODA									
Lolliguncula brevis		1					1	0.1	20
ANNELIDA and ASCHELMENTHES									
Arabellidae		1					1	0.1	50
Capitellidae		1					1	0.1	20
Glycindae solilaria		1					1	0.1	30
Nematoda	2	4	1	1			8	4.3	38
Nereidae		1	2				3	1.6	65
Nicolea simplex	2	20	4	1			27	14.4	71
Orbiniidae		1					1	0.1	5
PLANT									
Detritus		1					1	0.1	80
Spartina alterniflora				1			1	0.1	20
INORGANIC MATERIAL	1	13	1	4			19	10.1	70

Number of Stomachs: 226
Number and percent of stomachs containing food: 188 (83.2%)
Number and percent of empty stomachs: 38 (16.8%)

Table 174. The 10 most frequently occurring food items found in the stomachs of southern kingfish, *Menticirrhus americanus*, by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Sector	Winter Food Item	Winter No. Stomachs	Winter Percent Occurrence	Winter Average % Bolus	Spring Food Item	Spring No. Stomachs	Spring Percent Occurrence	Spring Average % Bolis	Summer Food Item	Summer No. Stomachs	Summer Percent Occurrence	Summer Average % Bolus
Creeks	NONE [1/]	-	-	-	Pisces	2	66.7	90	Crustacea	4	50.0	15
					Ophichthus ophis	1	33.3	90	Pisces	3	37.5	40
					Alpheus sp.	1	33.3	10	Amphipoda	1	12.5	90
									Penaeidae	1	12.5	70
									Annelida	1	12.5	70
									Mollusca	1	12.5	10
Sounds	Pisces	4	25.0	73	Pisces	6	30.0	68	Decapoda	13	34.2	52
	Crustacea	4	25.0	40	*Portunus gibbesii*	4	20.0	55	Pisces	11	28.9	43
	Acetes americanus	3	18.8	53	Amphipoda	4	20.0	53	*Squilla empusa*	7	18.4	54
	Unidentified material	2	12.5	90	Decapoda	3	15.0	43	*Palaemonetes* sp.	5	13.2	88
	Annelida	2	12.5	90	Crustacea	3	15.0	40	Annelida	4	10.5	48
	Mysidae	2	12.5	35	Annelida	2	10.0	55	Crustacea	4	10.5	40
	Nematoda	2	12.5	10	*Panopeus* sp.	2	10.0	55	*Portunus gibbesii*	3	7.9	43
	Anguilla rostrata	1	6.3	90	Unidentified material	2	10.0	50	Unidentified material	2	5.3	80
	Ovalipes ocellatus	1	6.3	90	*Pagurus longicarpus*	1	5.0	90	Bivalvia	2	5.3	55
	Plant detritus	1	6.3	80	*Paralichthys dentatus*	1	5.0	90	*Panopeus* sp.	2	5.3	35
Beaches	Annelida	13	50.0	79	*Penaeus setiferus*	19	40.4	78	*Portunus gibbesii*	2	50.0	55
	Unidentified material	7	26.9	74	Pisces	6	12.8	75	*Squilla empusa*	1	25.0	90
	Crustacea	3	11.5	60	Unidentified material	5	10.6	62	*Stellifer lanceolatus*	1	25.0	90
	Bivalvia	3	11.5	40	Crustacea	5	10.6	32	*Ophichthus ophis*	1	25.0	70
	Penaeus setiferus	2	7.7	90	Decapoda	5	10.6	32				
	Nematoda	2	7.7	70	*Panopeus* sp.	4	8.5	65				
	Decapoda	2	7.7	50	*Ovalipes ocellatus*	4	8.5	38				
	Amphipoda	2	7.7	5	*Callianassa atlantica*	3	6.4	57				
	Arenaeus cribrarius	1	3.8	90	*Pagurus longicarpus*	2	4.3	60				
					Annelida	2	4.3	25				
Offshore	*Emerita talpoida*	2	66.7	65	NONE	-	-	-	NONE	-	-	-
	Crustacea	2	66.7	40								
	Nematoda	2	66.7	5								
	Arabellidae	1	33.3	50								
	Unidentified material	1	33.3	20								
Totals	Annelida	15	33.3	81	*Penaeus setiferus*	19	27.1	78	Pisces	14	28.0	42
	Unidentified material	10	22.2	72	Pisces	14	20.0	74	Decapoda	13	26.0	52
	Crustacea	9	20.0	47	Decapoda	8	11.4	36	*Squilla empusa*	8	16.0	59
	Nematoda	6	13.3	38	Crustacea	8	1.4	35	Crustacea	8	16.0	28
	Pisces	4	8.9	73	Unidentified material	7	10.0	59	*Palaemonetes* sp.	5	10.0	88
	Acetes americanus	3	6.7	53	*Panopeus* sp.	6	8.6	62	*Portunus gibbesii*	5	10.0	48
	Bivalvia	3	6.7	40	*Portunus gibbesii*	5	7.1	62	*Ophichthus ophis*	2	4.0	80
	Penaeus setiferus	2	4.4	90	Amphipoda	4	5.7	53	*Stellifer lanceolatus*	2	4.0	70
	Emerita talpoida	2	4.4	50	Annelida	4	5.7	40	Penaeidae	2	4.0	55
	Decapoda	2	4.4	50	*Ovalipes ocellatus*	4	5.7	38	*Panopeus* sp.	2	4.0	35

[1/] None denotes no specimens were collected with food in stomachs.

Table 174. (continued)

Sector	Fall: Food Item	Fall: No. Stomachs	Fall: Percent Occurrence	Fall: Average % Bolus	Combined Totals: Food Item	Combined Totals: No. Stomachs	Combined Totals: Percent Occurrence	Combined Totals: Average % Bolus
Creeks	Crustacea	2	50.0	10	Crustacea	6	40.0	13
	Symphurus plagiusa	1	25.0	90	Pisces	5	33.3	60
	Callinectes sapidus	1	25.0	90	Decapoda	1	6.7	90
	Squilla empusa	1	25.0	90	*Ophichthus ophis*	1	6.7	90
	Decapoda	1	25.0	90	*Callinectes sapidus*	1	6.7	90
					Squilla empusa	1	6.7	90
					Symphurus plagiusa	1	6.7	90
					Amphipoda	1	6.7	90
					Penaeidae	1	6.7	70
					Annelida	1	6.7	70
Sounds	Pisces	5	35.7	48	Pisces	26	29.5	54
	Trachypeneus constrictus	4	28.6	75	Decapoda	16	18.2	51
	Penaeidae	3	21.4	70	Crustacea	11	12.5	40
	Nereidae	2	14.3	55	Annelida	10	11.4	51
	Mysidae	2	14.3	25	*Palaemonetes* sp.	7	8.0	74
	Annelida	2	14.3	15	*Squilla empusa*	7	8.0	56
	Cyathura polita	1	7.1	90	*Portunus gibbesii*	7	8.0	50
	Callianassa atlantica	1	7.1	90	Unidentified material	6	6.8	73
	Symphurus plagiusa	1	7.1	70	*Trachypeneus constrictus*	5	5.7	72
	Palaemonetes sp.	1	7.1	70	*Panopeus* sp.	5	5.7	52
Beaches	Crustacea	2	40.0	70	*Penaeus setiferus*	21	25.6	80
	Acetes americanus	2	40.0	50	Annelida	16	19.5	73
	Penaeidae	1	20.0	90	Unidentified material	12	14.6	69
	Annelida	1	20.0	90	Crustacea	10	12.2	48
	Pisces	1	20.0	50	Pisces	7	8.5	71
					Decapoda	7	8.5	37
					Panopeus sp.	4	4.9	65
					Bivalvia	4	4.9	53
					Ovalipes ocellatus	4	4.9	38
					Nematoda	4	4.9	35
Offshore	NONE [1/]	-	-	-	*Emerita talpoida*	2	50.0	65
					Crustacea	2	50.0	40
					Nematoda	2	50.0	5
					Arabellidae	1	25.0	50
					Unidentified material	1	25.0	20
Totals	Pisces	6	26.1	48	Pisces	38	20.2	58
	Trachypeneus constrictus	4	17.4	75	Crustacea	29	15.4	37
	Penaeidae	4	17.4	73	Annelida	27	14.4	65
	Crustacea	4	17.4	40	Decapoda	24	28.8	48
	Annelida	3	13.0	40	*Penaeus setiferus*	21	11.2	80
	Symphurus plagiusa	2	8.7	80	Unidentified material	19	10.1	68
	Nereidae	2	8.7	55	*Portunus gibbesii*	10	5.3	55
	Acetes americanus	2	8.7	50	*Squilla empusa*	9	4.8	62
	Mysidae	2	8.7	25	*Panopeus* sp.	9	4.8	58
	Callinectes sapidus	1	4.3	90	*Palaemonetes* sp.	8	4.3	76

[1/] None denotes no specimens were collected with food in stomachs.

shrimp (*Penaeus setiferus*). However, two other crustaceans, the common mud crab (*Panopeus* sp.) and lady crab (*Ovalipes oceallatus*), were also important. Annelids, fish, and mollusks were secondary food items in samples collected from the beaches. Although only four stomach samples were collected from offshore waters, the mole crab (*Emertia talpoida*) was found in two of these four specimens.

Welsh and Breder (1924) found that the stomach contents of southern kingfish 2.8 to 5.8 cm at Boca Grande, Florida consisted of schizopodus forms (85%), fish (6%), and polychaete worms (2%). In specimens 12-25 cm the major foods were polychaete worms (24%) and shrimp (20%), but crabs were also consumed. They concluded that the southern kingfish diet is equally divided between crustaceans and polychaete worms (possibly *Nereius*) with occasional slight quantities of small fish.

Bearden (1963) looked at the food habits of South Carolina southern kingfish and found that the most frequently occurring food items for all size groups were crustaceans and marine annelid worms (polychaetes). In specimens 15-80 mm SL annelid worms, mysid shrimp, amphipods and shrimp larvae occurred in over 36% of the stomachs. In specimens 81-135 mm major foods were annelid worms and shrimp with over 44% occurrence. However, crabs, amphipods, shrimp larvae and mysid shrimp were also important with over 16.8% occurrence. Specimens 135-200 mm fed mainly on shrimp, annelid worms and crabs, while specimens 201-280 mm fed mainly on shrimp and crabs.

Seasonal feeding activity from fall through spring showed near equal food consumption rates with over 84.3% of the stomachs containing food (Table 175). The percentage dropped slightly in summer to 79.4%, but the reason is unknown.

Feeding activity was high in all sectors as over 75% of the stomachs in each sector contained food (Table 175). Greatest feeding activity was in the creeks and along the beaches as 88.2% of the stomachs contained food. In the sounds, the percentage was only slightly lower at 78.6%. Although only four specimens were collected from offshore waters, 75% contained food.

Table 175. Number and percent of southern kingfish, *Menticirrhus americanus*, with stomachs containing food versus empty stomachs by season and sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Creeks						Sounds						Beaches					
	Food		Empty		Total		Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	0	0.0	1	100.0	1	100.0	16	88.9	2	11.1	18	100.0	26	86.7	4	13.3	30	100.0
Spring	3	100.0	0	0.0	3	100.0	20	71.4	8	26.6	28	100.0	47	90.4	5	9.6	52	100.0
Summer	8	88.9	1	11.1	9	100.0	38	79.2	10	20.8	48	100.0	4	66.7	2	33.3	6	100.0
Fall	4	100.0	0	0.0	4	100.0	14	77.8	4	22.2	18	100.0	5	100.0	0	0.0	5	100.0
Total	15	88.2	2	11.8	17	100.0	88	78.6	24	21.4	112	100.0	82	88.2	11	11.8	93	100.0

	Offshore						Combined Sectors					
	Food		Empty		Total		Food		Empty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Winter	3	75.0	1	25.0	4	100.0	45	84.9	8	15.1	53	100.0
Spring	-	-	-	-	-	-	70	84.3	13	15.7	83	100.0
Summer	-	-	-	-	-	-	50	79.4	13	20.6	63	100.0
Fall	-	-	-	-	-	-	23	85.2	4	14.8	27	100.0
Total	3	75.0	1	25.0	4	100.0	188	83.2	38	16.8	226	100.0

Water temperature apparently had little effect on the feeding activity of southern kingfish (Table 50). At temperatures from 11 to 35°C over 76.9% of the stomachs examined contained food from each temperature gradient. Although the percentage dropped slightly to 66.7% at temperatures below 10°C, only three specimens were collected and accurate conclusions from such small samples cannot be drawn.

In relation to lunar phase, peak feeding activity apparently took place during the three days prior to new moon and during the three day period before last quarter as over 91% of the stomachs contained food (Table 51). Lowest feeding activity occurred during the three days following new moon, during the three day period after the first quarter, and during full moon when over 24% of the stomachs were empty. Further breakdown of feeding activity according to lunar phase is impractical because of low numbers collected during certain lunar phases.

GULF KINGFISH

The geographical distribution of the gulf kingfish (*Menticirrhus littoralis*) includes the Atlantic coast from south Florida to Chesapeake Bay, the Gulf of Mexico and continental coast of the Caribbean Sea, and the Atlantic coast of South America southward to Rio Grande, Brazil (Fischer, 1978). Gulf kingfish, also known as beach or surf whiting, prefer smooth sand bottom areas along the beaches and nearshore ocean waters, and they seldom occur inside the estuaries.

Movement and Migration

Only 10 gulf kingfish were tagged in the estuarine waters of Glynn County, Georgia. Length frequencies in 50 mm length groups are presented in Table 176. Lengths (TL) of gulf kingfish tagged with Howitt tags ranged from 220 to 277 mm and those tagged with Floy tags ranged from 176 to 293 mm. Table 177 lists the length frequencies of gulf kingfish collected for tagging in 20 mm groups by gear type.

Since none of the 10 tagged gulf kingfish were recovered, recovery information was not available to ascertain movement for this species

Table 176. Total number tagged and the return rates for Howitt or Floy tags and for tags combined in 50 mm length groups for gulf kingfish, *Menticirrhus littoralis*, tagged in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Howitt Tag			Floy Tag			Combined		
	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured	Number Tagged	Number Returned	Percent Recaptured
175				1			1		
225	1			2			3		
275	1			5			6		
Total	2	0	0.0	8	0	0.0	10	0	0.0

Table 177. Number of gulf kingfish, *Menticirrhus littoralis*, tagged by length group and by gear used in capture for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Length Group (mm)	Gill Net 1/ (2 in)	Trawl	Hook and Line	Totals
170	-	1	-	1
190	-	-	-	-
210	-	1	-	1
230	-	-	-	-
250	1	-	2	3
270	2	1	-	3
290	1	1	-	2
Totals	4	4	2	10

1/ Gill net sizes are stretch mesh measurements.

(Table 14). However, based on release information, gulf kingfish occur primarily on beaches and in offshore waters during spring, summer, and early fall.

Length-Weight Relationship

The length-weight relationship for 28 gulf kingfish, ranging from 176 to 298 mm and 51 to 289 g, was $\log W = 2.872 \log L - 4.675$. The correlation coefficient value for length-weight for this species was 0.8054 ($P < 0.0001$). Least-squares regression analyses of the length-weight relationships for females, males, and all gulf kingfish combined are shown in Table 24. Figure 42 illustrates the length-weight relationships for gulf kingfish. Greatest lengths recorded for males and females were 217 and 298 mm, respectively. The heaviest specimens weighed 117 g for males and 298 g for females.

Age and Growth

Scales and otolith sections from 34 gulf kingfish ranging from 176 to 298 mm were examined, and 28 (92%) were considered to be legible for age analyses. Scale characteristics described for southern kingfish were similar to that for gulf kingfish and were considered as the criteria for recognition of annuli on gulf kingfish scales. Scale and otolith ring formations were simultaneous.

Although the total number of gulf kingfish collected was insufficient to document the number and time of annuli formations, calculations of mean monthly growth of marginal increments indicated that scale annuli were formed only once annually during March through May.

Least-squares regression analyses on the relationship between fish length and scale radius yielded an r^2 value of 0.25 ($P < 0.0077$). Back-calculations of fish length at time of annulus formation were performed, and empirical and mean back-calculated total lengths at age for gulf kingfish are shown in Table 178. Weighted back-calculated lengths for male, female and all kingfish combined are presented in Table 179.

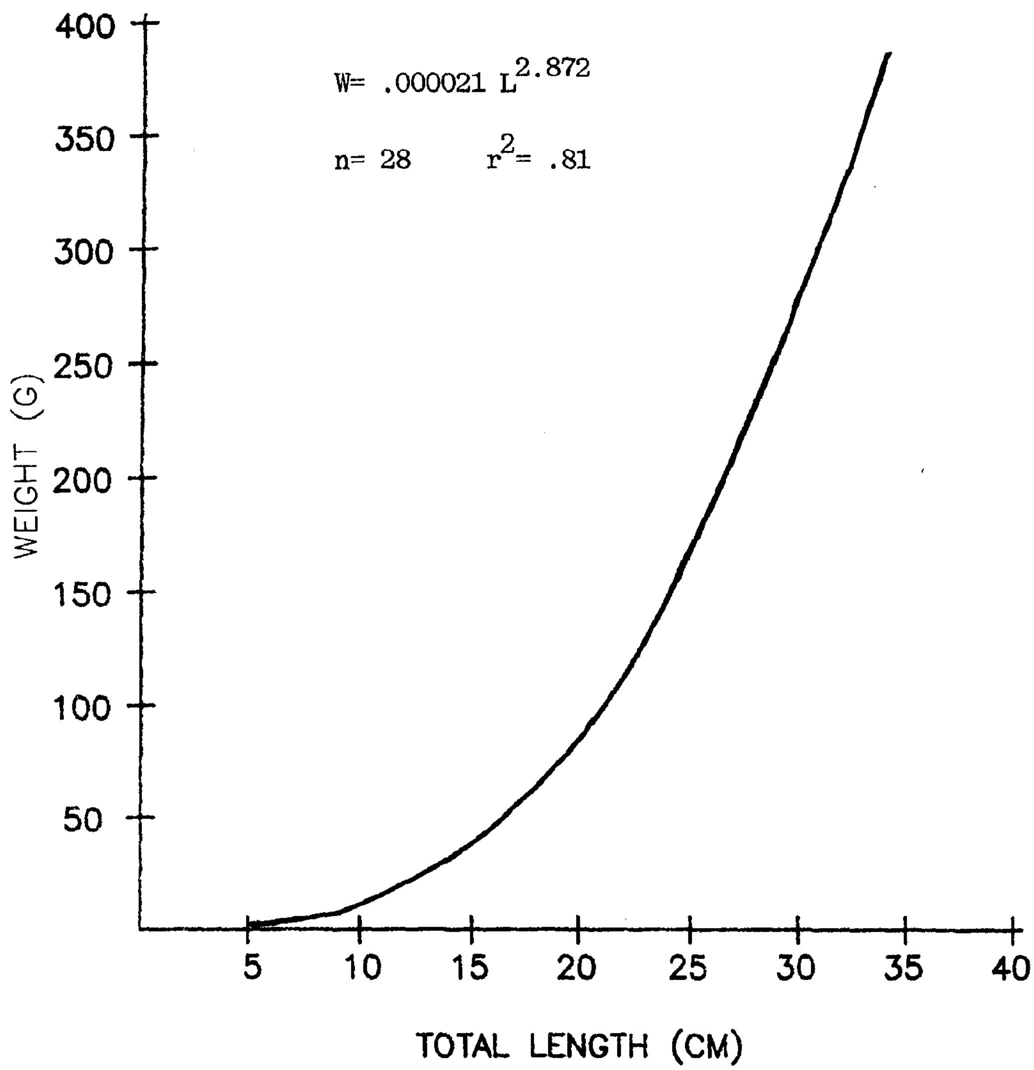

Figure 42. Length-weight relationship of gulf kingfish, *Menticirrhus littoralis*, collected in Glynn County, Georgia from January 1979 through June 1982.

Table 178. Mean back-calculated total lengths for Gulf kingfish, *Menticirrhus littoralis*, collected in the coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Age	Number	Length Range at Capture	Mean Length at Capture	Mean Back-Calculated Lengths of Successive Scale Rings	
				1	2
0	1	176	176		
1	22	214 - 263	236	113	
2	5	248 - 298	284	150	266
	Weighted Means			120	266
	Growth Increments			120	146

NOTE: Lengths measured in millimeters.

Table 179. Number, empirical and back-calculated total lengths, and growth increments by sex and age for Gulf kingfish, *Menticirrhus littoralis*, collected in coastal waters of Glynn County, Georgia from January 1979 through June 1982.

Sex	Age 1	Age 2
Juveniles		
Number	None Collected	
Mean Length at Capture		
Back-Calculated Length		
Growth Increment		
Males		
Number	2	
Mean Length at Capture	215	
Back-Calculated Length	97	
Growth Increment	97	
Females		
Number	20	5
Mean Length at Capture	238	284
Back-Calculated Length	122	266
Growth Increment	122	144
Combined		
Number	22	5
Mean Length at Capture	236	284
Back-Calculated Length	120	266
Growth Increment	120	146

NOTE: Lengths measured in millimeters.

Maturity and Spawning

Relatively low numbers of gulf kingfish were collected during the study due to their seasonality and distinct preference for the beaches and surf zone. The smallest specimens for which sex could be determined through gross examination were a 213 mm female and a 214 mm male. Both of these specimens were age I, or in their second year of life. The smallest female exhibiting developing gonads (stage III or higher) was a 292 mm specimen (age II). The only male found exhibiting advanced maturity was a 326 mm specimen, and the only ripe female collected was a 292 mm specimen (age II).

Age at maturity was first considered to be in the third or fourth summer (Welsh and Breder, 1924). However, Lunz (1955) later reported that maturity is reached in the second or third year. Bearden (1963) reported that it is possible that sexual maturity for gulf kingfish is similar to that of southern kingfish, which he judged to be probably two years old or slightly less for males and approximately two to three years for females. His assumptions were based on gonadal inspection of both species.

Various stages of gonadal development for gulf kingfish are presented by month and sex in Table 180. Of 37 mature specimens collected, 62.2% exhibited "resting stage" gonads while 32.4% were in relatively early stages of development (stages II and III). Only two specimens exhibited advanced maturity. These two specimens were a ripe female and a ripe male which were collected in the surf zone on the beach at Christmas Creek on Cumberland Island in April from water temperature of $20^{\circ}C$ and salinity of 22 $^{o}/oo$ (Tables 181 and 182). Close proximity to the Satilla River, a major coastal plains freshwater river drainage system, plus normal tidal exchange from Christmas Creek probably accounted for the occurrence of these spawners in relatively low salinity waters. The overall average salinity along the beaches in Glynn County, Georgia during this survey was 28.8 $^{o}/oo$ (Table 37).

Hildebrand and Cable (1934) reported that spawning begins at Beaufort, North Carolina no later than the first of May and continues into August,

Table 180. Number of gulf kingfish, *Menticirrhus littoralis*, collected by month, sex and reproductive stage for the period January 1979 through June 1982.

	Reproductive Stage													
	I		II		III		IV		V		VI		VII	
Month	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January														
February														
March														
April					2	1					1	1		
May			3	0										
June														
July														
August	21	2	6	0										
September														
October														
November														
December														

Table 181. Stages of gonadal development for Gulf kingfish, *Menticirrhus littoralis*, by month, sex and salinity gradient for fish collected in Glynn County, Georgia from January 1979 through June 1982.

		Surface Water Salinity (0/00)																	
	Reproductive	0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		Totals	
Month	State	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
January	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
April	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	2	1
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VI	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	1
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	1	0	1	0	-	-	2	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
July	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
August	I	-	-	-	-	-	-	-	-	-	-	-	-	21	2	-	-	21	2
	II	-	-	-	-	-	-	-	-	-	-	-	-	7	0	-	-	7	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December	I-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	I	-	-	-	-	-	-	-	-	-	-	-	-	21	2	-	-	21	2
	II	-	-	-	-	-	-	-	-	-	-	1	0	8	0	-	-	9	0
	III	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	2	1
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VI	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	1
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 182. Stages of gonadal development for Gulf kingfish, *Menticirrhus littoralis*, by water temperature and salinity gradients for fish collected in Glynn County, Georgia from January 1979 through June 1982.

Salinity (0/00)	Reproductive Stage	Surface Water Temperature (°C) 0-5		6-10		11-15		16-20		21-25		26-30		31-35		Totals	
		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
21-25	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	2	1	-	-	-	-	-	-	2	1
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VI	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	1
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-30	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-35	I	-	-	-	-	-	-	-	-	-	-	-	-	21	2	21	2
	II	-	-	-	-	-	-	-	-	1	0	2	0	5	0	8	0
	III-VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	I	-	-	-	-	-	-	-	-	-	-	-	-	21	2	21	2
	II	-	-	-	-	-	-	-	-	1	0	3	0	5	0	9	0
	III	-	-	-	-	-	-	2	1	-	-	-	-	-	-	2	1
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VI	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	1
	VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

and that it seemed almost certain that spawning occurs only in the open outside waters. Their conclusions were based on the rare occurrence of adults in spawning condition in inside waters. Lunz (1955) reported that all three species of kingfish spawn in outside waters in South Carolina with the possibility of some spawning in the sounds. Mahood et al, (1974) reported in a previous trawling and gillnet study along the Georgia coast that gulf kingfish were collected in all months with peak abundance in March and April. However, they failed to collect young specimens during seining activities in inside waters, and were therefore unable to report a spawning season for this species. Bearden (1963) reported that spawning presumably occurs at the same time in South Carolina as was previously reported by Hildebrand and Cable (1934) for Beaufort, North Carolina. His presumption was based on the collection of a wide size range (25-90 mm SL) of young during the fall.

The absence of gulf kingfish exhibiting advanced reproductive stages of gonadal development in Georgia estuaries prohibited detailed analyses of fecundity (Table 40). However, fecundity was estimated to be approximately 216,750 eggs for one age II, 292 mm specimen. Total weight of this fish was 289 g, and its ovaries comprised approximately 24% (68.3 g) of its total body weight.

Food Preference and Feeding Habits

The gulf kingfish, or surf whiting, occurs in much lower numbers than the southern kingfish or common whiting. Of 35 gulf kingfish stomachs examined to determine food preferences and feeding habits, 28 (80%) contained food and 7 (20%) were empty. The contents of stomachs containing food are presented by fish size in 100 mm groupings in Table 183. No specimens <100 mm were found with food in their stomachs. Although only two specimens 101-200 mm had ingested food, amphipods and bivalve mollusks were found in their stomachs. In specimens 201-300 mm the major foods were annelid worms, mollusks and crustaceans. Mysid shrimp and lady crabs (*Ovalipes ocellatus*) were the most frequently occurring crustaceans although the small crab (*Pinnixa chaetopterana*) was also found. The polychaete worm (*Nicolea simplex*) was the most frequently occurring species

Table 183. Stomach contents of gulf kingfish, *Menticirrhus littoralis*, collected in Glynn County Georgia from January 1979 through June 1982.

Food Item	Length Group 101-200	Length Group 201-300	Length Group 301-400	Combined	Percent Occurrence	Average % Bolus
ARTHROPODA						
Crustacea		16	1	17	60.7	35
Amphipoda	1			1	3.6	70
Decapoda		1		1	3.6	10
Haustoriidae		1		1	3.6	5
Mysidae		2		2	7.1	5
Ovalipes ocellatus		2		2	7.1	75
Pinnixa chaetopterana		1		1	3.6	10
MOLLUSCA						
Mollusca		9		9	32.1	36
Fossor conquina (Donax variabilis)			1	1	3.6	90
Bivalvia	1			1	3.6	20
Tellinidae		1		1	3.6	50
ANNELIDA						
Eunicidae		1		1	3.6	10
Nicolea simplex		14		14	50.0	46
PLANT						
Detritus			1	1	3.6	90

Number of stomachs: 35
Number and percent of stomachs containing food: 28 (80.0%)
Number and percent of empty stomachs: 7 (20.0%)

ingested by this size group. Too few specimens were collected for fish >301 mm to determine feeding habits, but the small mollusk, *Donax variabilis*, was found in one specimen.

The gulf kingfish occurs seasonally in Georgia, appearing in the spring and peaking in abundance during summer. Consequently, no specimens were collected for food habits studies during fall and winter. Furthermore, since it prefers the surf zone along the beaches, no specimens were collected from the creeks and sounds. It occurs so infrequently in inland waters that many anglers do not know that there are two species of kingfish in our waters.

The 10 most frequently occurring food items ingested by this species are presented by season and sector in Table 184. In general, major foods were crustaceans, annelid worms and mollusks. The most frequently occurring crustacean was the lady crab (*Ovalipes ocellatus*). Although mollusks were ingested, only the small coquina (*Fossor coquina*) was identified. During spring, lady crabs and mysid shrimp were the most frequently ingested crustaceans although other crabs (*Pinnixa* sp.) and digger amphipods were also observed (Table 184). Coquina shells were the most commonly occurring mollusk. During summer the main foods were crustaceans, annelid worms, and mollusks. Other items of lower occurrence included amphipods and tellin shells.

Insufficient samples of gulf kingfish were collected to correlate water temperature or lunar phase with feeding activities. The data collected are presented in Tables 50 and 51.

Bearden (1963) found that juvenile gulf kingfish in South Carolina waters had fed almost entirely on beach fleas (*Orchestia* sp.), and the adults contained fish remains, mole crabs (*Emerita* sp.) and stomatopod (*Squilla* sp.) remains.

MISCELLANEOUS SPECIES

In addition to those species selected for this study, 116 specimens of 11 additional species were tagged in limited numbers. Information on the number released and recaptured, time at large, and distance traveled

Table 184. The 10 most frequently occurring food items found in the stomachs of gulf kingfish, *Menticirrhus littoralis*, by season and by sector for fish collected in Glynn County, Georgia from January 1979 through June 1982.

	Winter				Spring				Summer			
Sector	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus
Creeks	NONE[1/]	-	-	-	NONE	-	-	-	NONE	-	-	-
Sounds	NONE	-	-	-	NONE	-	-	-	NONE	-	-	-
Beaches	NONE	-	-	-	*Ovalipes ocellatus*	2	50.0	75	Crustacea	16	66.7	31
					Mysidae	2	50.0	5	Annelida	14	58.3	46
					Fossor conquina	1	25.0	90	Mollusca	9	37.5	35
					Crustacea	1	25.0	90	Plant detritus	1	4.2	90
					Decapoda	1	25.0	10	Amphipoda	1	4.2	70
					Pinnixa sp.	1	25.0	10	Tellinadae	1	4.2	50
					Eunicidae	1	25.0	10	Bivalvia	1	4.2	20
					Haustoriidae	1	25.0	<5				
Offshore	NONE	-	-	-	NONE	-	-	-	NONE	-	-	-
Totals	NONE	-	-	-	*Ovalipes ocellatus*	2	50.0	75	Crustacea	16	66.7	31
					Mysidae	2	50.0	5	Annelida	14	58.3	46
					Fossor coquina	1	25.0	90	Mollusca	9	37.5	35
					Crustacea	1	25.0	90	Plant detritus	1	4.2	90
					Decapoda	1	25.0	10	Amphipoda	1	4.2	70
					Pinnixa sp.	1	25.0	10	Tellinadae	1	4.2	50
					Eunicidae	1	25.0	10	Bivalvia	1	4.2	20
					Haustoriidae	1	25.0	<5				

[1/] None denotes no specimens were collected with food in stomachs.

Table 184. (continued)

	Fall				Combined Totals			
Sector	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus	Food Item	No. Stomachs	Percent Occurrence	Average % Bolus
Creeks	NONE [1/]	-	-	-	NONE	-	-	-
Sounds	NONE	-	-	-	NONE	-	-	-
Beaches	NONE	-	-	-	Crustacea	17	60.7	35
					Annelida	14	50.0	46
					Mollusca	9	32.1	36
					Ovalipes ocellatus	2	7.1	75
					Mysidae	2	7.1	5
					Plant detritus	1	3.6	90
					Fossor coquina	1	3.6	90
					Amphipoda	1	3.6	70
					Tellinidae	1	3.6	50
					Bivalvia	1	3.6	20
Offshore	NONE	-	-	-	NONE	-	-	-
Totals	NONE	-	-	-	Crustacea	17	60.7	35
					Annelida	14	50.0	46
					Mollusca	9	32.1	36
					Ovalipes ocellatus	2	7.1	75
					Mysidae	2	7.1	5
					Plant detritus	1	3.6	90
					Fossor coquina	1	3.6	90
					Amphipoda	1	3.6	70
					Tellinidae	1	3.6	50
					Bivalvia	1	3.6	20

[1/] None denotes no specimens were collected with food in stomachs.

for each of these species are presented in Table 185. Of these additional species tagged, individuals of only five species were recovered.

One of five tagged Atlantic sturgeon (*Acipenser oxyrhynchus*) was recaptured. This 610 mm (TL) individual was released in the St. Andrew estuarine system during January and traveled 37 km before being recaptured six days later by a shad fisherman in the delta portion of the Altamaha River.

Thirty-five rock seabass (*Centropristis philadelphica*) were tagged, but only two (5.7%) were recovered. Both recaptures were released during October in St. Simons Sound and recaptured in ocean waters by commercial shrimp trawlers. One was at large three days and recaptured approximately 12 km offshore from Jekyll Island. The other specimen was at large 18 days and recaptured in the St. Simons Sound channel after traveling 5.5 km. The lengths of these seabass when released were 252 and 262 mm, respectively.

One of ten tagged striped mullet (*Mugil cephalus*) was recaptured. This specimen was released during February in Clubbs Creek in the St. Simons estuarine system and recaptured 393 days later by project personnel in the same area of release. The female mullet measured 290 mm (FL) when released and was 323 mm when recaptured -- a growth of 33 mm.

Of five tripletail (*Lobotes surinamensis*) tagged, only one was recaptured. This individual was released during August in St. Andrew Sound and traveled 490 km before it was recaptured 600 days later by a commercial fisherman longlining for swordfish in the Gulf Stream off Ft. Pierce, Florida. It was gaffed while lazily swimming underneath a longline buoy. This specimen had measured 462 mm (TL) when released and reportedly measured 34 inches (860 mm) when recaptured -- a growth of 434 mm.

The remaining six species tagged did not produce any reported recoveries.

Table 185. Number tagged, number and percent recaptured and days at large and distance traveled for fish tagged in addition to the target species.

Species	Number Tagged	Number Recaptured	Percent Returned	Days at Large		Distance Traveled (km)	
				Average	Maximum	Average	Maximum
Atlantic sturgeon *(Acipenser oxyrhynchus)*	5	1	20.0	6	6	37	37
Black sea bass *(Centropristis striata)*	5	0	0.0				
Bluefish *(Pomatomus saltatrix)*	5	0	0.0				
Florida Pompano *(Trachinotus carolinus)*	3	0	0.0				
Gray snapper *(Lutjanus griseus)*	2	0	0.0				
Gulf flounder *(Paralichthys albigutta)*	1	0	0.0				
Rock seabass *(Centropristis philadelphica)*	35	2	5.7	11	18	9	12
Spotted hake *(Urophycis regia)*	30	0	0.0				
Striped mullet *(Mugil cephalus)*	10	1	10.0	393	393	0	0
Tripletail *(Lobotes surinamensis)*	5	1	20.0	600	600	489	489
Silver seatrout *(Cynoscion nothus)*	15	0	0.0				

SUMMARY

Spotted seatrout are Georgia's most popular inshore recreational species. Personnel tagged 3,381 seatrout and received 456 (13.5%) returns. Recreational fishermen were the major producer of tag recoveries with 68%, while commercial fishermen produced only 0.9%. Movement was seasonal and generally short range, averaging only 8.9 km. Approximately 90% of all recoveries were recaptured within 25 km of the tagging site. Maximum distance traveled was 110 km. Seatrout are generally estuarine specific and in many cases they seem oriented to particular river systems. Recapture lengths ranged from 268 to 735 mm with an average length of 414 mm. Maximum ages observed were age VIII for females and VI for males. Spawning took place in the lower estuary and along the beaches from April through August, peaking in May and June at water temperatures and salinities above 21°C and 26 °/oo, respectively. Hermaphroditism was observed in eight specimens, but represented <1% of all specimens examined. Feeding habits changed with increase in size from smaller crustaceans to penaeid shrimp to predominantly fish in the largest specimens.

Weakfish or "summer trout" rank moderately as a recreational fish species and are generally taken by bottom fishermen. Only 48 (1.6%) of the 2,958 tagged weakfish were returned and recreational fishermen accounted for only 17 (35.4%) recoveries. Most (54.5%) creel-sized recoveries ranged from 350 to 500 mm, and 95% (43) of the recoveries were recaptured within 25 km of the tagging site. Average and maximum distances traveled were 8.3 and 167 km, respectively. Most spawning activity apparently took place in ocean waters, but advanced maturities were collected in the lower portions of St. Simons Sound with peak occurrence in April, when 29.4% of the females exhibited advanced ovarian development. Preferred foods for smaller weakfish (<200 mm) were crustaceans and anchovies, but larger specimens showed a definite preference for menhaden and penaeid shrimp.

Red drum or "channel bass" are very popular with anglers, but population size is relatively small in comparison with species such as spotted seatrout, croaker and weakfish. Only 368 red drum were tagged, but 79 (21.5%) were recaptured, indicating very high fishing pressure on the first four year classes. Return rates for individual size groups ranged as high as 28.9%. Average movement was 14.2 km, and 88.6% of the recoveries were caught within 25 km of the tagging site. Maximum distance traveled was 178 km. Creel lengths of recaptures ranged from 311 to 659 mm, averaging 447 mm. Spawning apparently took place at sea during fall and early winter when adults left the surf zone and moved seaward. No advanced gonadal development was observed. Small red drum (<200 mm) ate primarily crustaceans. However, as they increased in size (301 - 800 mm) fish were also incorporated into the diet.

Of 1,181 southern flounder tagged, only 75 (6.4%) were recaptured, indicating that this species is probably underharvested by recreational anglers. Anglers caught only 41 (54.7%) of the recaptures. Maximum distance traveled was 556 km, and average distance was 53.8 km. Lengths of recreational recaptures ranged 222 - 436 mm, averaging 340 mm. Spawning apparently occurred in ocean waters during fall and early winter as only one specimen with developing gonads was collected in inshore waters. Small southern flounder (<200 mm) ate both fish and crustaceans, but larger creel size specimens showed a definite preference for fish.

The population of creel size summer flounder in Georgia's coastal waters is very small. Of 141 summer flounder tagged, only 1 (0.7%) was recaptured. This particular specimen was caught by a commercial shrimp trawler in ocean waters. Of 23 summer flounder aged, only one specimen had formed an annulus, indicating that fish over age I generally move out of the estuaries. Only three mature females were collected, and these exhibited resting (stage I) ovaries. Small summer flounder fed predominantly on crustaceans, but specimens 201 - 300 mm also fed on squid.

Of 352 black drum tagged, 92 (26.1%) were recaptured. Maximum distance traveled was 619 km and average distance was 41.2 km. Approximately 84% of the recoveries were collected within 25 km of the tagging site. Lengths of recreational recoveries ranged from 251 to 400 mm. Spawning took place primarily during March and April at salinities >21 $^{o}/oo$ and temperatures 16 - 25^{o}C. Small drum fed mainly on decapod crustaceans and annelid worms (polychaetes), but mollusks became important with increase in size. The largest adults preferred crabs and bivalve mollusks.

Of 416 sheepshead tagged, only 30 (7.2%) were recaptured, indicating low fishing pressure. Returns were only from recreational fishermen (76.7%) and project personnel (23.3%). Movement was generally short range as 93% (28) of the returns were captured within 25 km of the tagging site. Recapture lengths ranged 192 - 393 mm, averaging 300 mm. Spawning activity was apparently centered in offshore waters from March through May as no spawning activity was observed in inland waters. Little difference existed in the diet of different size groups except for a greater inclusion of mollusks, echinoderms and urochordates with increase in size. Crustaceans and mollusks were the staple food source for all size groups.

Croaker had a very low return rate as only 2.5% (87) of the 3,456 tagged specimens were recaptured. Approximately 48% of the recaptures were recaptured in the immediate area of release, and 92% were caught within 25 km. Maximum movement was 179 km and average movement was 10.9 km. Lengths of recreational recaptures ranged from 200 - 300 mm. Apparently, most croaker over one to two years of age moved out of the estuaries. Spawning activity probably extended from August to April, with the peak during September and October. Advanced maturity was observed at temperatures <28^{o}C and salinity >16 $^{o}/oo$. Small croaker (<200 mm) fed mainly on crustaceans and annelid worms (polychaetes), and the largest specimens included limited amounts of fish in their diets.

Spot ranked very low as a recreational species. Of 793 tagged, only 13 (1.6%) were recovered, and only one (7.7%) of these was taken by a recreational fisherman. Movement averaged 14.2 km with a maximum distance of 118 km. No spawning activity was observed in inland waters, and spawning apparently took place in ocean waters during late fall and winter. Primary foods were annelid worms, mollusks and crustaceans, but most small invertebrates were susceptible to ingestion.

Only 26 (4.8%) of the 540 tagged southern kingfish were recovered. Average distance traveled was 44.1 km, although one specimen traveled 537 km. Approximately 74% of all recoveries were recaptured within 25 km of the tagging site. Commercial fishermen accounted for 57.7% of the recoveries. Spawning development apparently began in March and continued through September with the peak in late spring. Most spawning apparently took place in ocean waters although some spawning activity may have occurred in the lower sounds. Small southern kingfish fed on small mollusks, crustaceans and annelid worms, but fish also became important in larger specimens.

Gulf kingfish were collected seasonally during warm months. Only 10 specimens were tagged, and no recoveries were obtained. Spawning information was limited, but spawning activity apparently took place at sea during spring and summer. Annelid worms, mollusks and crustaceans were found in stomach contents.

RECOMMENDATIONS

To insure that wise and prudent management decisions relative to Georgia's marine recreational fishery will be made in the future, consideration should be given to the following recommendations:

1. Establish a daily creel limit of two (2) red drum per person, and a possession limit of four (4) per person for red drum measuring over thirty (30) inches total length. This recommendation is proposed to insure adequate protection of spawning size red drum from overexploitation. Reported catches of adult reds have apparently declined during the past decade. Since the adults tend to congregate in relatively few areas of the surf zone, they are highly susceptible to overexploitation. Also, since large specimens rank relatively low in palatability due to course textured and strong flavored flesh, such protective measures will be beneficial in preventing wanton waste of these potential spawners. Furthermore, market values for adult reds are so low in comparison with other species that fishermen making large catches generally have no ready market and often have to give them away.

2. Establish a minimum size limit of twelve (12) inches total length for the minimum creel length of red drum. The growth rate for this species is so rapid that young specimens entering the hook and line fishery for the first time in mid-summer at approximately 10 inches length will be approximately 12 inches long by September. This measure basically gives these fish two more growing months by letting them reach 12 inches. Furthermore, many of these undersized fish that will be released as a result of this measure will be

recaptured the next season at a much larger size of approximately 20 inches or three pounds. Such a minimum size limit will help create a higher total yield per recruit for this species. Furthermore, those small red drum that are not recaptured a second time could possibly survive to serve as brood stock at a later date.

3. Establish a continuing standardized finfish monitoring program for the major inshore recreational fish species to determine current population levels and evaluate future population trends. Such a data base would establish catch per unit effort values that can be linked with recreational fishery statistics to determine fishing pressure on individual stocks so that practical management strategies can be practiced.
4. Continue life history studies on red drum with special emphasis on the reproductive biology. This would entail expanding the study area to include Georgia's oceanic waters as it is assumed that this is the location of most spawning activity.
5. Conduct a comprehensive marine recreational fishery survey of coastal Georgia to determine the extent, value and relative fishing pressure being exerted by the marine recreational fishery. This initial survey would establish a data base that will be used for comparison of future periodic surveys to determine trends in the recreational fishery as well as fishing pressure being exerted on individual fish populations. Such information is absolutely necessary for proper management of Georgia's recreational fishery.
6. Continue the status quo regarding commercial gillnetting activity in Georgia. This would include prohibiting any additional gillnetting activities in Georgia's coastal

waters. At present, gillnetting is not allowed for any fish species other than shad and sturgeon during the commercial season opened specifically for these species. From the strong evidence of territorality in spotted seatrout, the estuarine dependence and general lack of movement of red drum <4 years of age, and from the apparently already depleted population of red drum in Georgia's coastal waters, it is highly probable that increased gillnetting activity would have an adverse impact on these two most popular inshore fish species.

Georgia's sounds are relatively small in relation to the much larger sounds and bays of other states where gillnetting is legal. Gillnetting in Georgia could quickly result in overfishing of these recreationally important inshore species. Gillnetting activities would be focused on the shoreline oyster beds currently being targeted by recreational anglers, resulting in conflicts between the two user groups. Several states with legalized gillnetting are currently faced with the problem of managing depleted fish stocks -- attributed to overfishing, and trying to resolve conflicts between commercial and recreational user groups. Management strategies have generally resulted in allocation of the resources between the user groups. Hopefully, if Georgia maintains the status quo this will not be a problem and recreational fishermen can continue to enjoy top quality fishing.

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